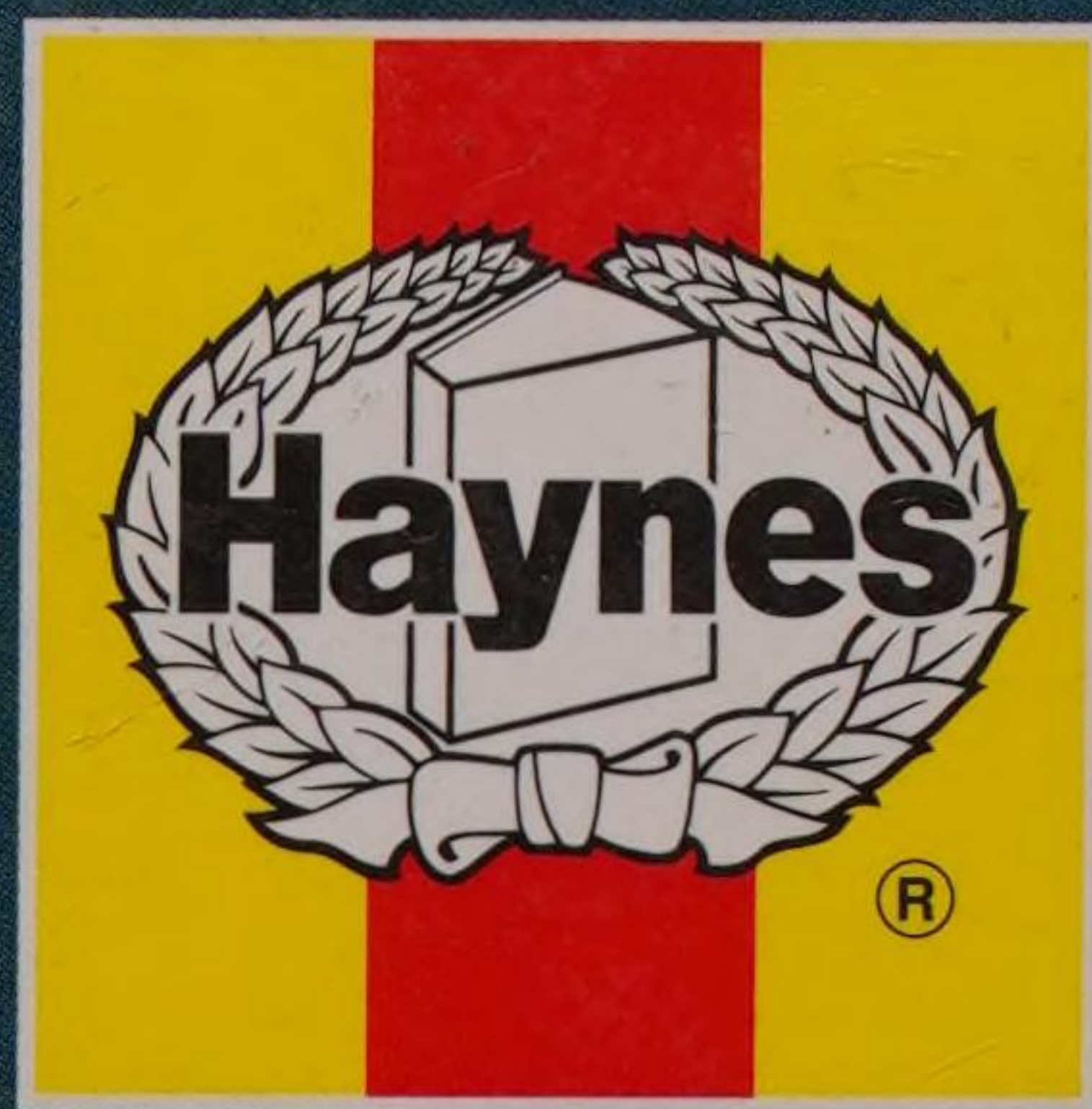
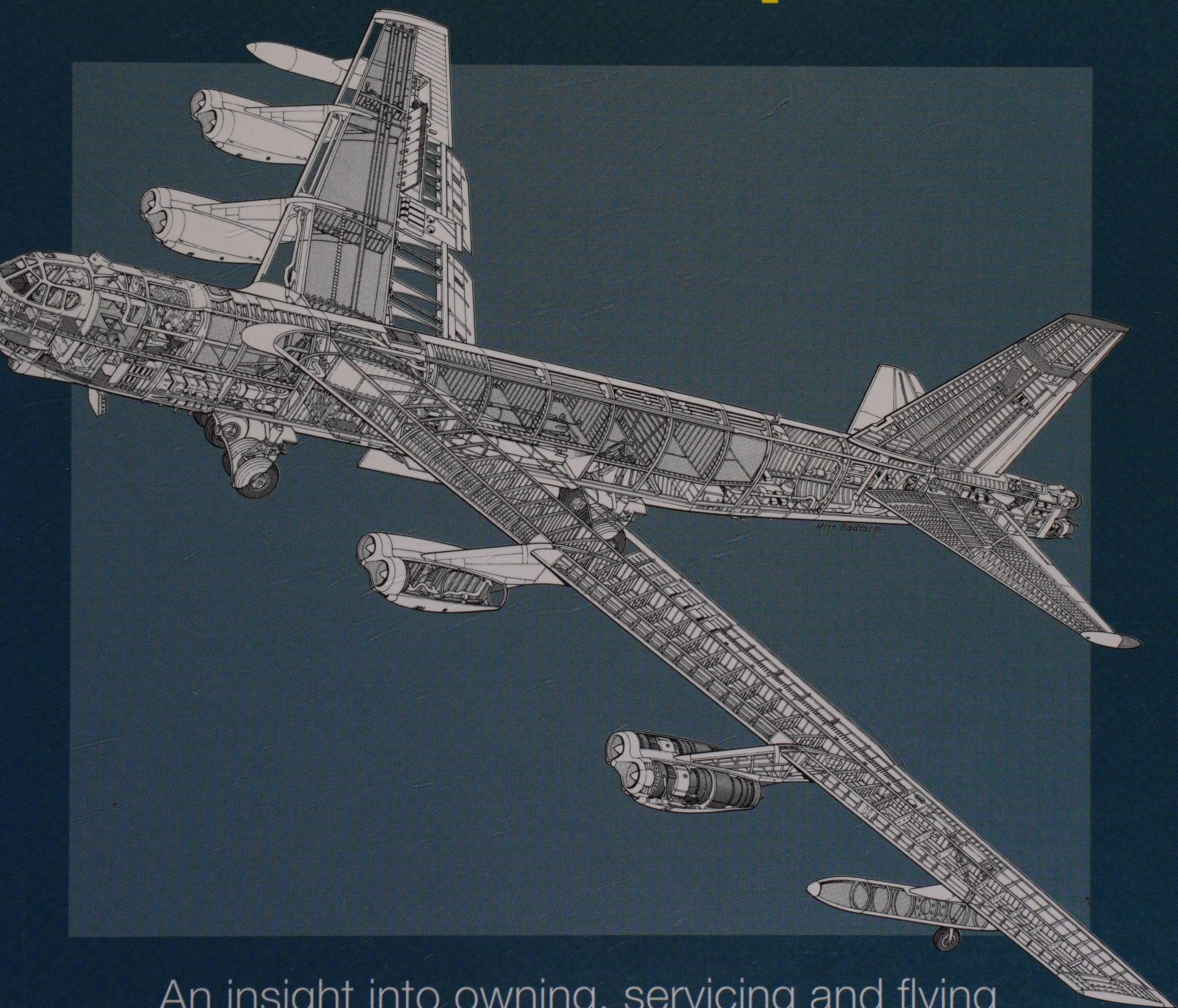


BOEING B-52 STRATOFORTRESS



1952 onwards (all marks)

Owners' Workshop Manual



An insight into owning, servicing and flying
the USAF Cold War strategic bomber

BOEING B-52 STRATOFORTRESS



1952 onwards (all marks)

COVER CUTAWAY: *Mike Badrocke*

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Steve Davies has asserted his moral right to be identified as the author of this work.

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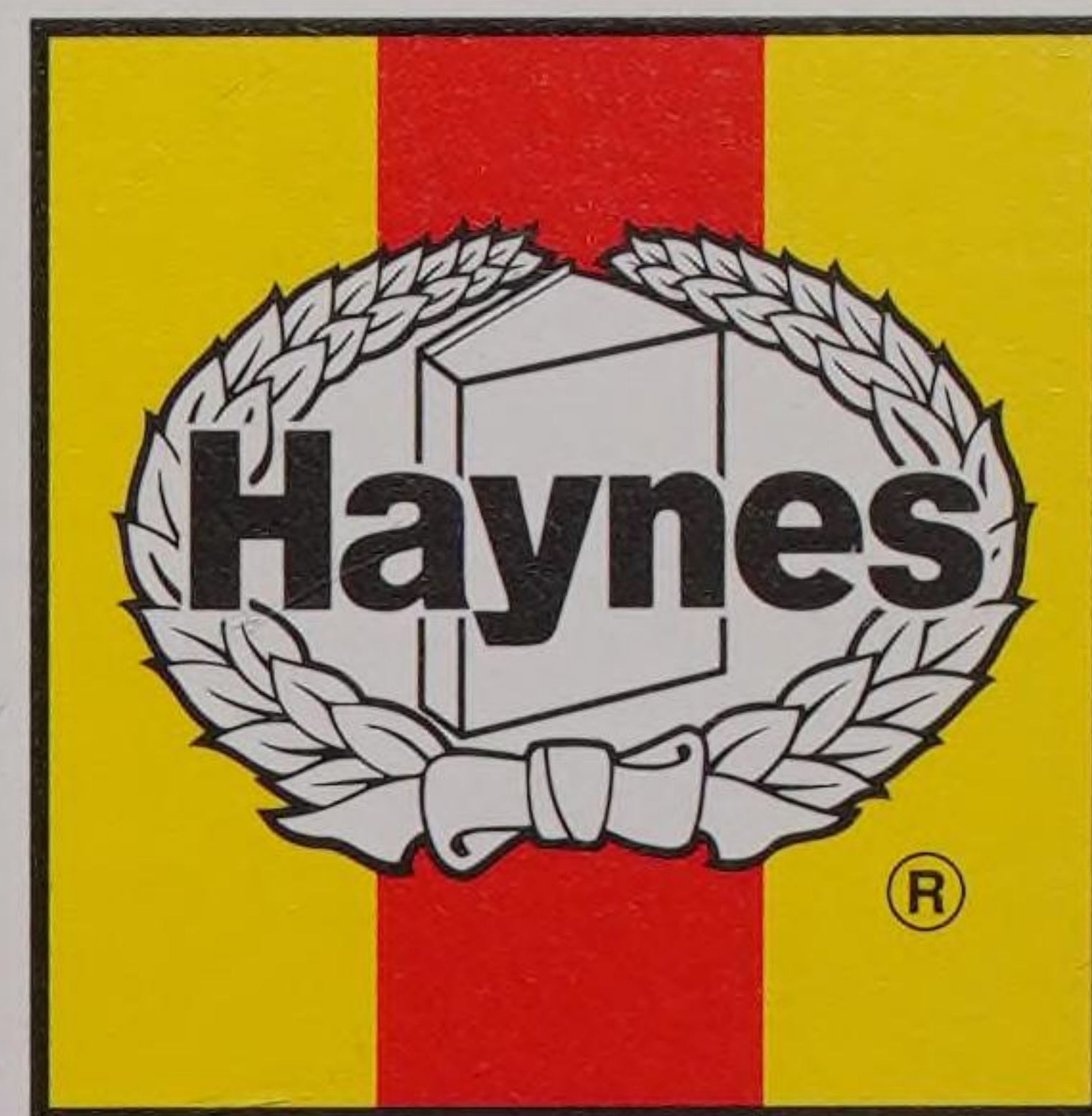
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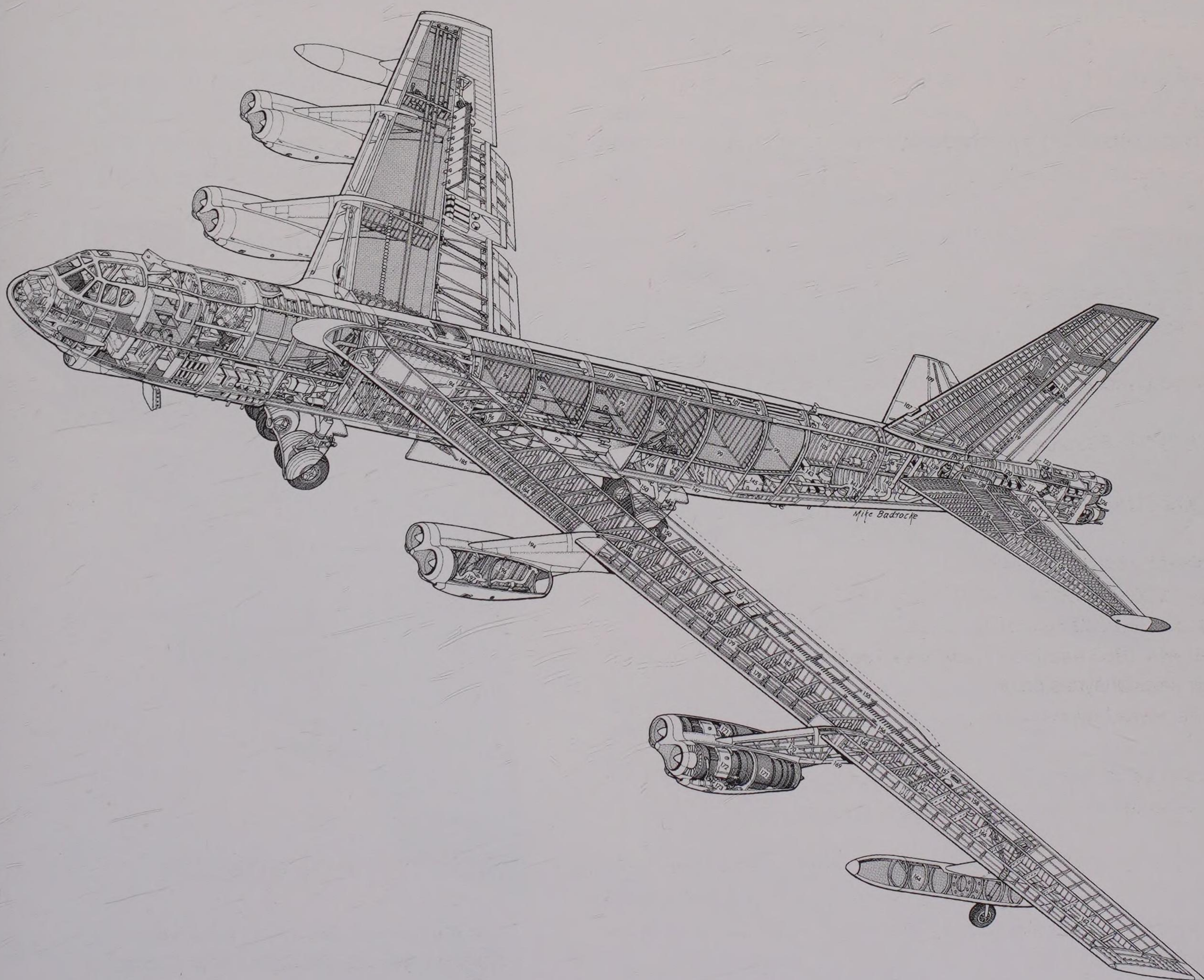
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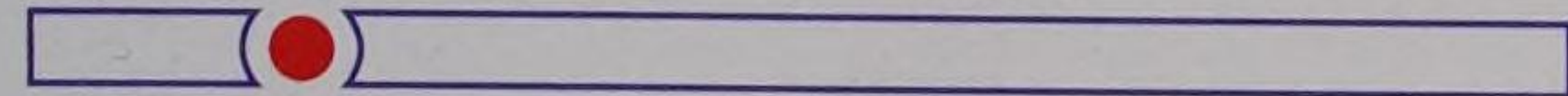


An insight into owning, servicing and flying the
USAF Cold War strategic bomber aircraft

Steve Davies



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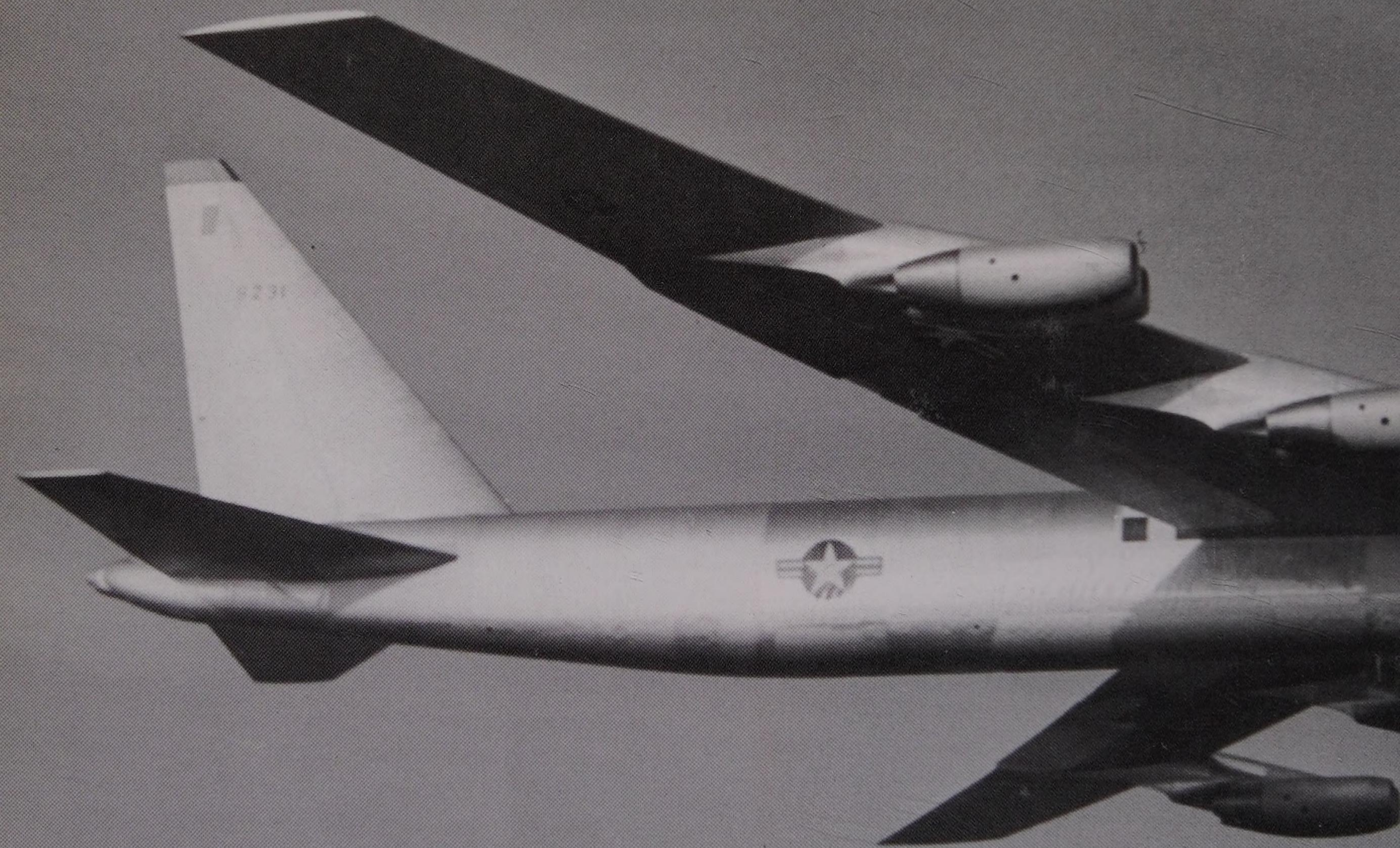
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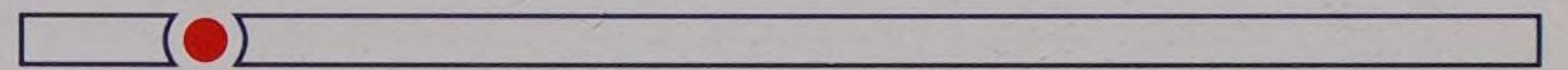
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OPPOSITE The unmistakable shape of the B-52. The aircraft seen here is a B-52H based at Barksdale Air Force Base, Louisiana, in 2001. *(Rex Features)*



Chapter One

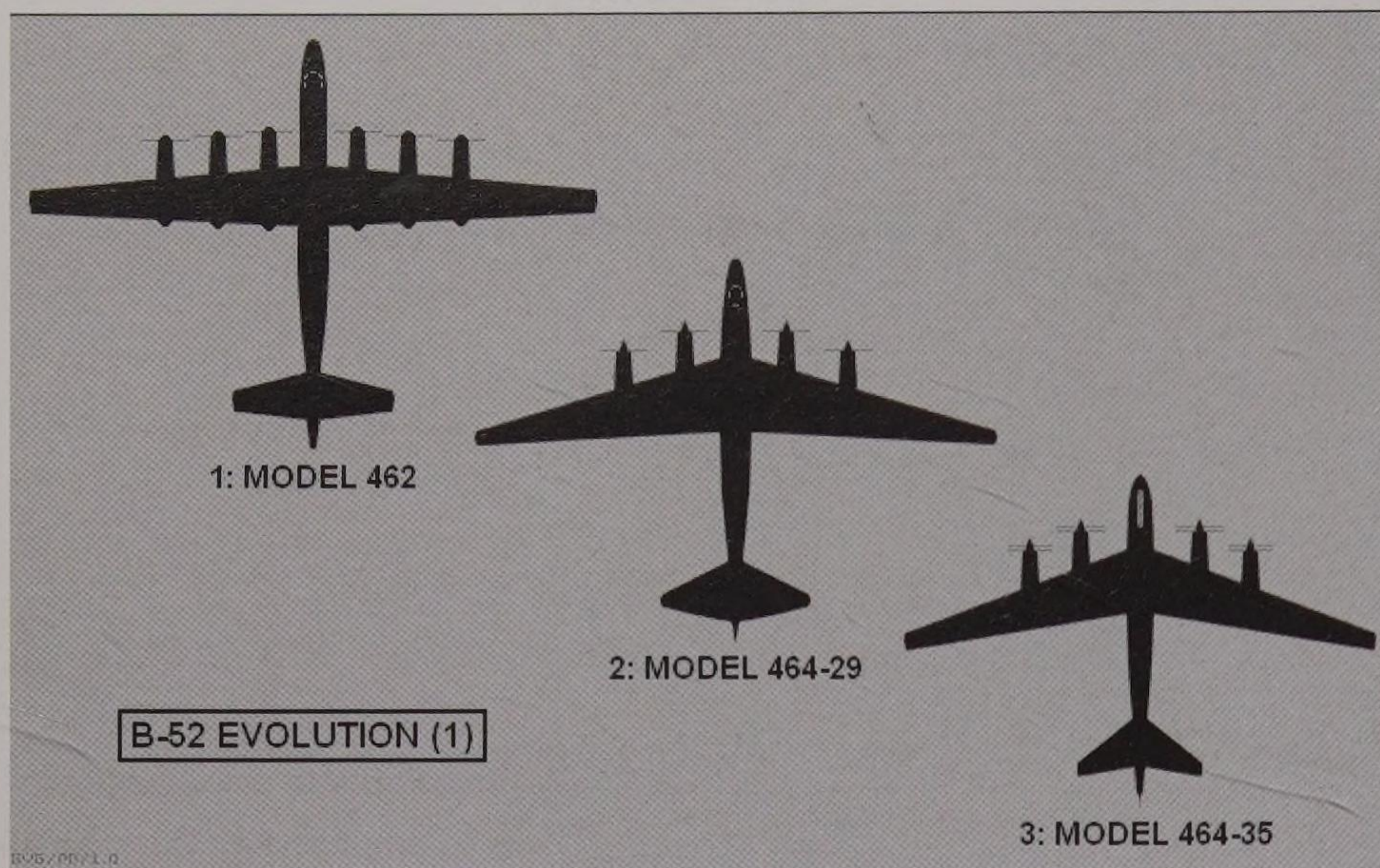
Early design and development



In July 1948, Boeing – one of America's pre-eminent aircraft manufacturers – was contracted by the United States Air Force (USAF) to design and build a long-range, heavy bomber experimental aircraft. It would be designated the B-52.



OPPOSITE Both the YB-52 (pictured) and the XB-52 were constructed at Boeing's Plant 2, Boeing Field, Seattle. The 'Y' prefix indicated that the airframe was a prototype, although there was actually very little difference between it and the XB-52, which was instrumented to record flutter. (USAF)



ABOVE The B-52 development – from drawing board to first flight – involved an impressive number of iterations and permutations stemming from Boeing’s Model 462 design. (Greg V. Goebel – www.vectorsite.net)

Boeing had won the contract off the back of a successful bid for the USAF’s new strategic bomber competition. Air Materiel Command (AMC), one of the Air Force’s major command elements, had compiled a list of requirements for the bomber, specifying in 1945 that it should feature 20mm turrets for self-protection, a cruise speed of 230kt at 34,000ft, and a combat radius of at least 5,000 miles. AMC also required the bomber to be able to carry a 10,000lb payload of free-fall bombs.

Boeing had responded to the 1945 request for bids with the ‘Model 462’ design. It featured straight wings and, given the infancy of the jet engine, was powered by six Wright T35 turboprop engines. The T35 was a conversion of one of the first turbojet engines, the Lockheed J37, which had been built in the 1930s but had languished largely undeveloped

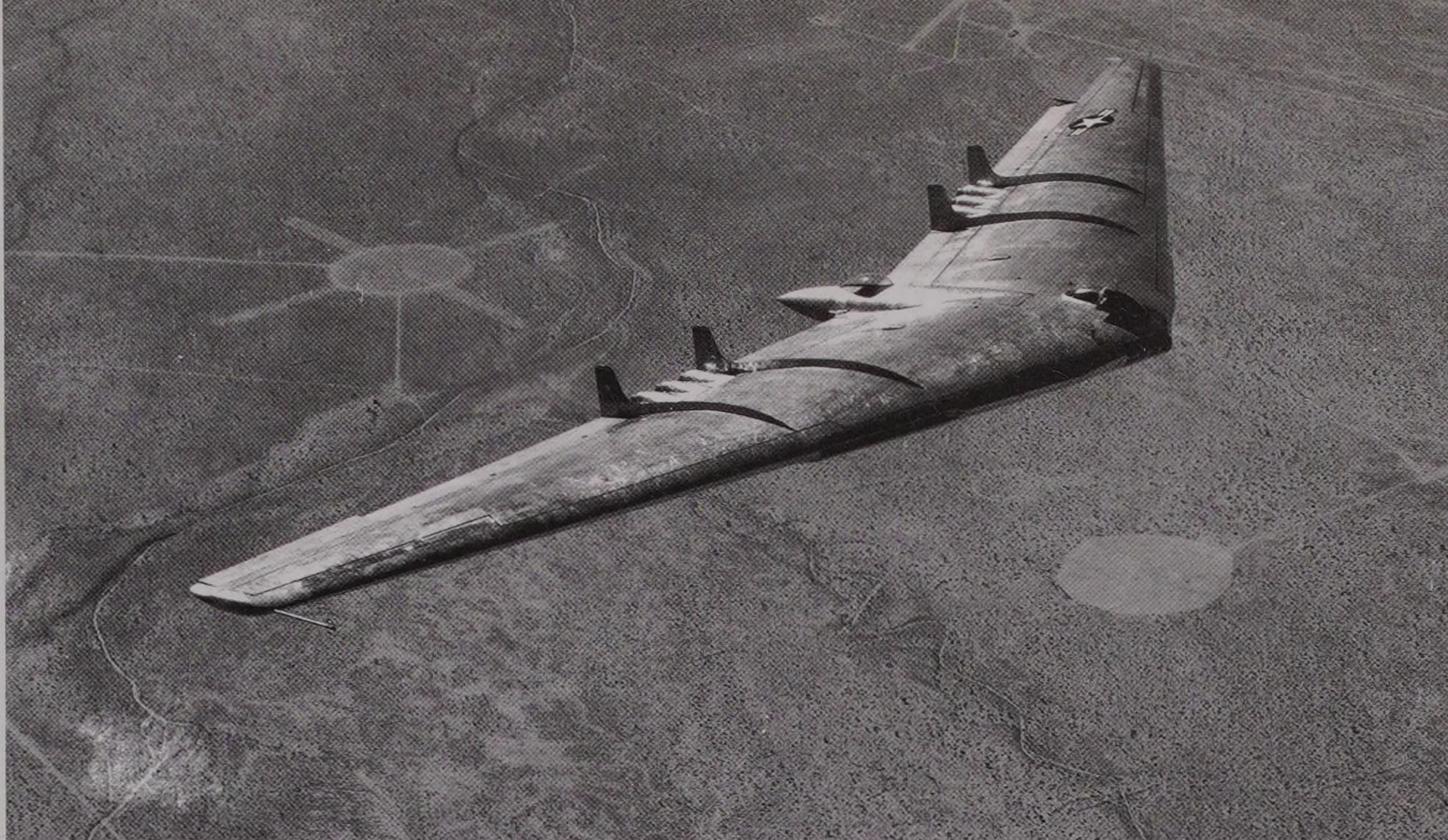
in the intervening years. The six engines gave the 300,000lb aircraft a combat radius of only 3,110 miles, which fell considerably short of the 5,000-mile requirement. Even so, it had been deemed good enough to beat the competition. Accordingly, the rival designs of Consolidated Aircraft and the Glenn L. Martin Company were rejected by the Air Force, and on 5 June 1946 Boeing’s design had been declared the winner.

Later that month Boeing received \$1.7m from the Air Force to build a full-scale mock-up of their design. However, as the summer progressed it was clear that the aircraft’s massive size, and limited performance relative to the original requirements, meant that the Model 462 – now referred to as the XB-52 – needed a dramatic redesign. The company responded with the swept-wing Model 464, which represented a scaled-down, four-engined version of their original design. It weighed in at 230,000lb.

With the arrival of winter, General Curtis LeMay – then Deputy Chief of Air Staff for Research and Development – began changing the requirements for the B-52, and in doing so added to the challenge of designing and building what would become the world’s longest-serving combat aircraft. In November, LeMay stated that the Air Force now wanted a maximum speed of 345kt. In December he again increased the requirement: now he wanted 345kt speed, a range of 12,000 miles, a nuclear strike capability and a maximum weight of 480,000lb. The constant changes to the Air Force’s requirements were symptomatic of the realisation that, if

RIGHT The Convair RB-36D, pictured here, boasted jet augmentation in the form of four General Electric J-47 jet engines mounted in pairs under its outer wing edges. The B-52 was designed to replace all versions of this intercontinental strategic bomber. (USAF)





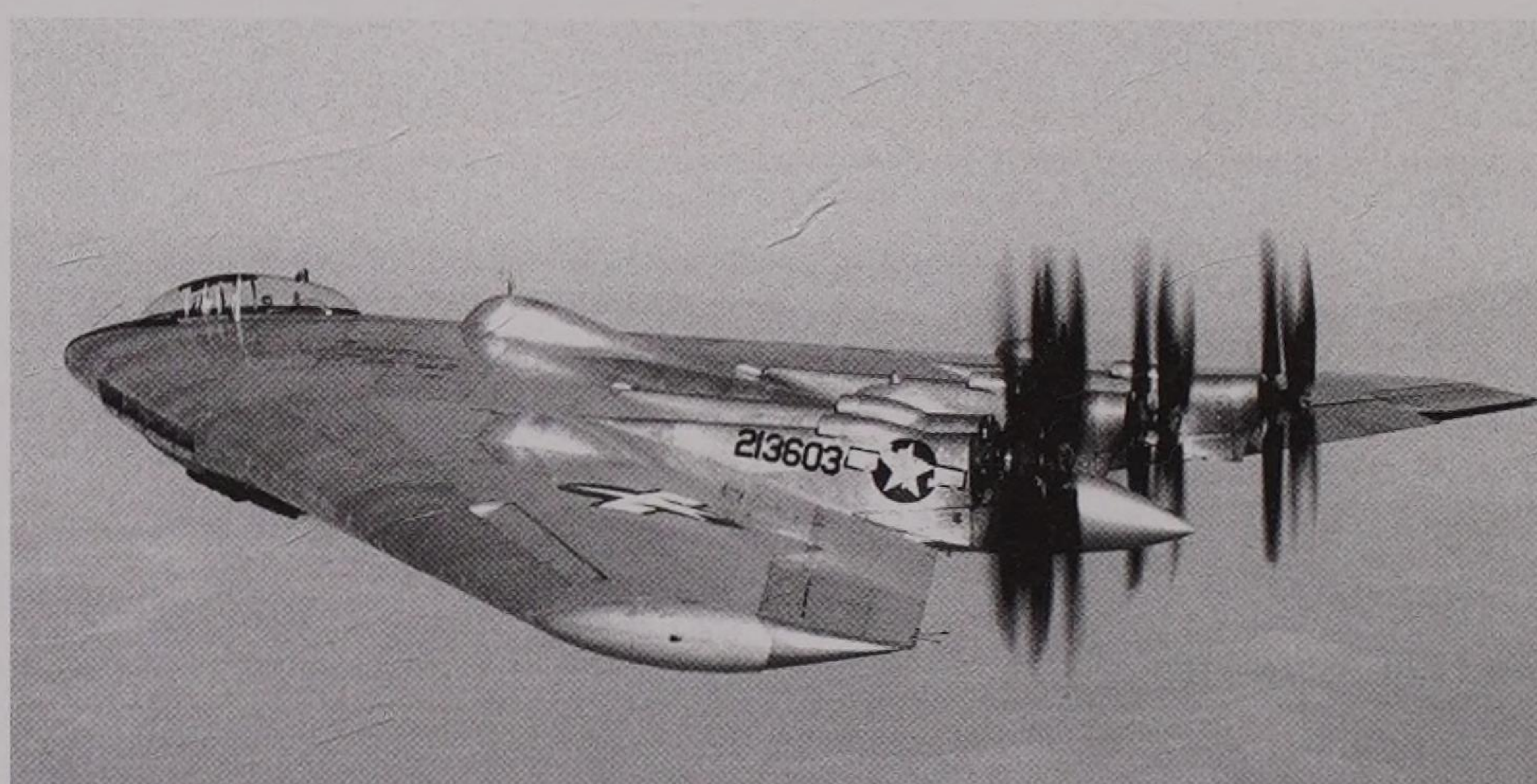
LEFT AND BELOW The YB-49 and YB-35 were exceptionally advanced for their time – it would take decades before the US Air Force finally purchased its first (and, to date, only) flying wing bomber, the Northrop B-2A Spirit. Problems with these two nascent bombers prompted the Air Force to place additional emphasis on Boeing's 494 design. (USAF)

the original specifications were not updated, America's new bomber would actually be no more capable than the Convair B-36 'Peacemaker' that it was designed to replace.

Boeing returned to the drawing board, this time offering two designs: the Model 464-16, which was a dedicated nuclear bomber; and the 464-17, a conventional bomber. Despite the latter design being able to carry only 9,000lb of munitions, LeMay selected it because it could be adapted to fly both conventional and nuclear missions. Despite these changes, it was now abundantly clear that the XB-52 would indeed offer no significant improvement over the Peacemaker. The Air Force halted the project.

Undaunted, Boeing continued to develop the design on its own time. As it did so, and against the backdrop of constantly changing requirements, a formal Air Force committee met in December to define the strategic bomber requirements once and for all. The cliff notes of this meeting were: 440kt maximum speed and 8,000 miles combat range.

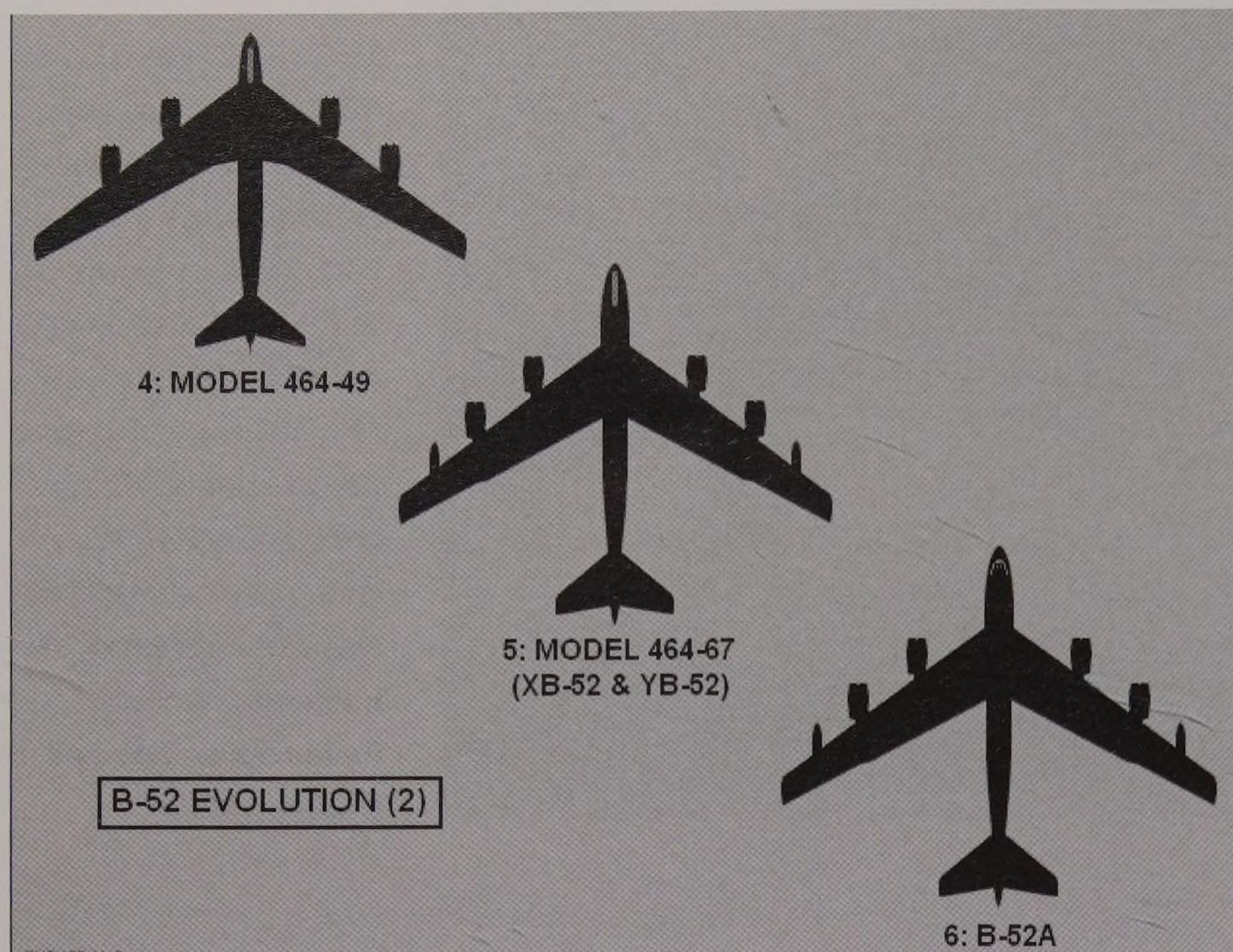
For Boeing, which had been making progress with the latest iteration of the Model 464 (the -29), this news was not encouraging. In the face of a complete cancellation of the programme, the company successfully petitioned the Secretary of the Air Force to keep it alive. Mindful of the problems that Northrop was experiencing with its two experimental flying-wing bombers, the YB-35 and YB-49, Boeing was instructed to consider all and any technological advances that could bring its bomber in line with the Air Force's needs.



Key among such developments was the jet engine. Although 1948 saw the Air Force order the company to incorporate these into its 494 design, Boeing's official history maintains that the company was already doing so: 'Ed Wells, Boeing vice president of Engineering, and George Schairer, chief of Aerodynamics, preferred jets for the B-52. Boeing Senior Vice President Wellwood Beal told the two to work up a new design using jets but not to do anything that would jeopardise the contract in hand for turboprops. The jet-powered B-52 was born in the Hotel Van Cleve in Dayton, Ohio, on an October weekend in 1948 ... Schairer called Wells, who arrived in Dayton that night.

'Back at the hotel, the team worked all night. Using the data that Schairer had brought along, they put together a design that incorporated jet engines but did not call for any major changes to the bomber's wing.' This iteration would be the -49, and would be powered by Westinghouse J40 turbojets.

'By late Friday night, they had laid out



BELOW LEFT AND RIGHT The YB-52 was rolled out on 15 March 1952 and took to the skies exactly one month later. Seen here in flight, the most notable external differences between it and the B-52H of today are the smaller vertical tail and redesigned cockpit arrangement. (USAF)

what was essentially a new airplane. The new design featured a wing that was swept back at 35 degrees with a 185-foot span. More significantly, it featured eight jet engines.' Boeing quickly hand-delivered the -49 proposal to an impressed US Air Force.

There would be other iterations of the 494 design before the first flight of the aircraft in 1952. The last, the -67, was increased in size in response to concerns about the fuel consumption of the turbojet engines and the knock-on effect this would have on its range. In combination with Boeing's extensive wind tunnel testing and aeroelastic testing, this final Model 494 submission was compelling enough for AMC to draw up a contract for 13 B-52As

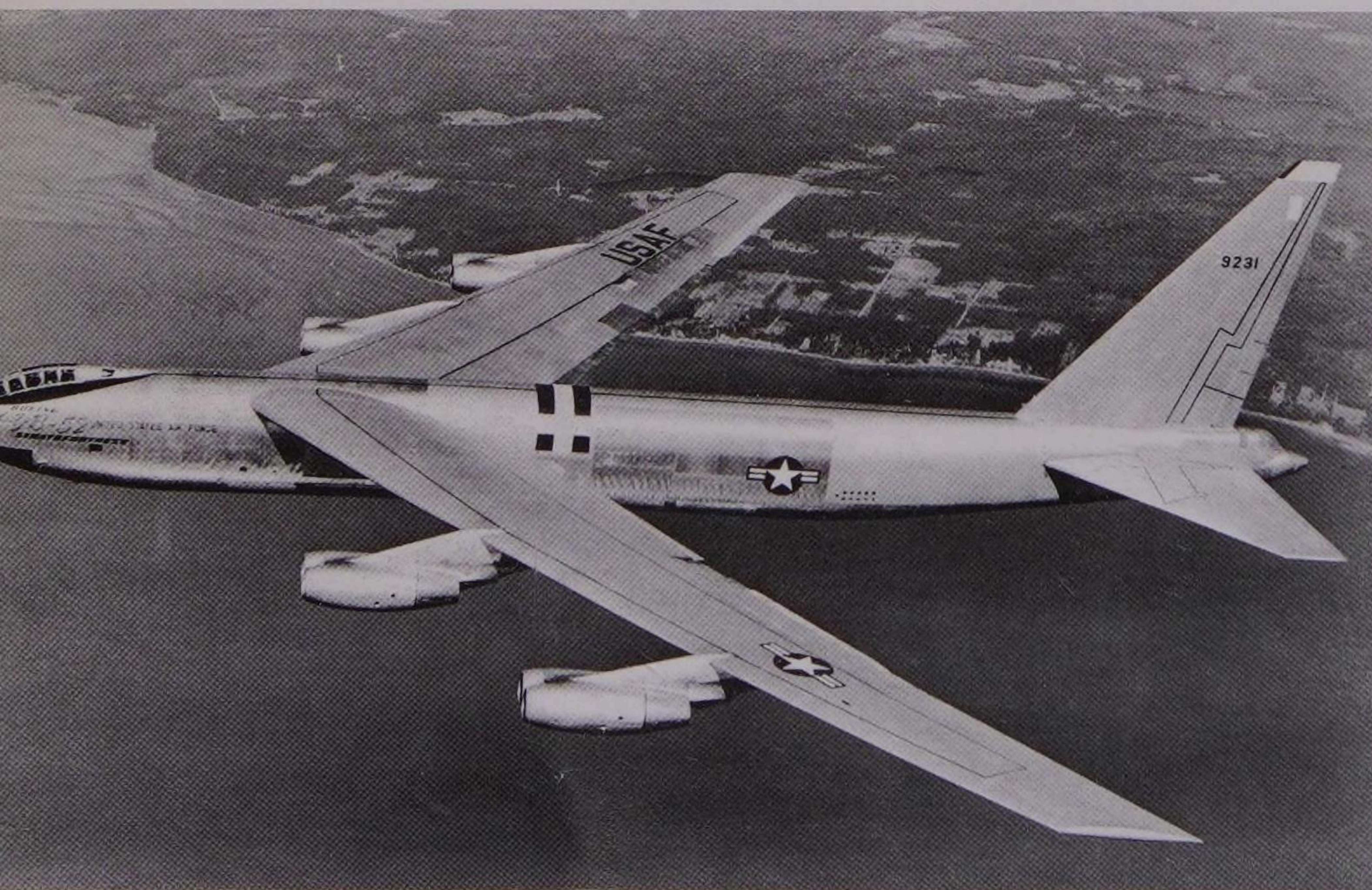
LEFT B-52 development continued, and the design now incorporated a significantly swept wing and turbojets in podded nacelles. Design 464-67 would result in the XB- and YB-52s.

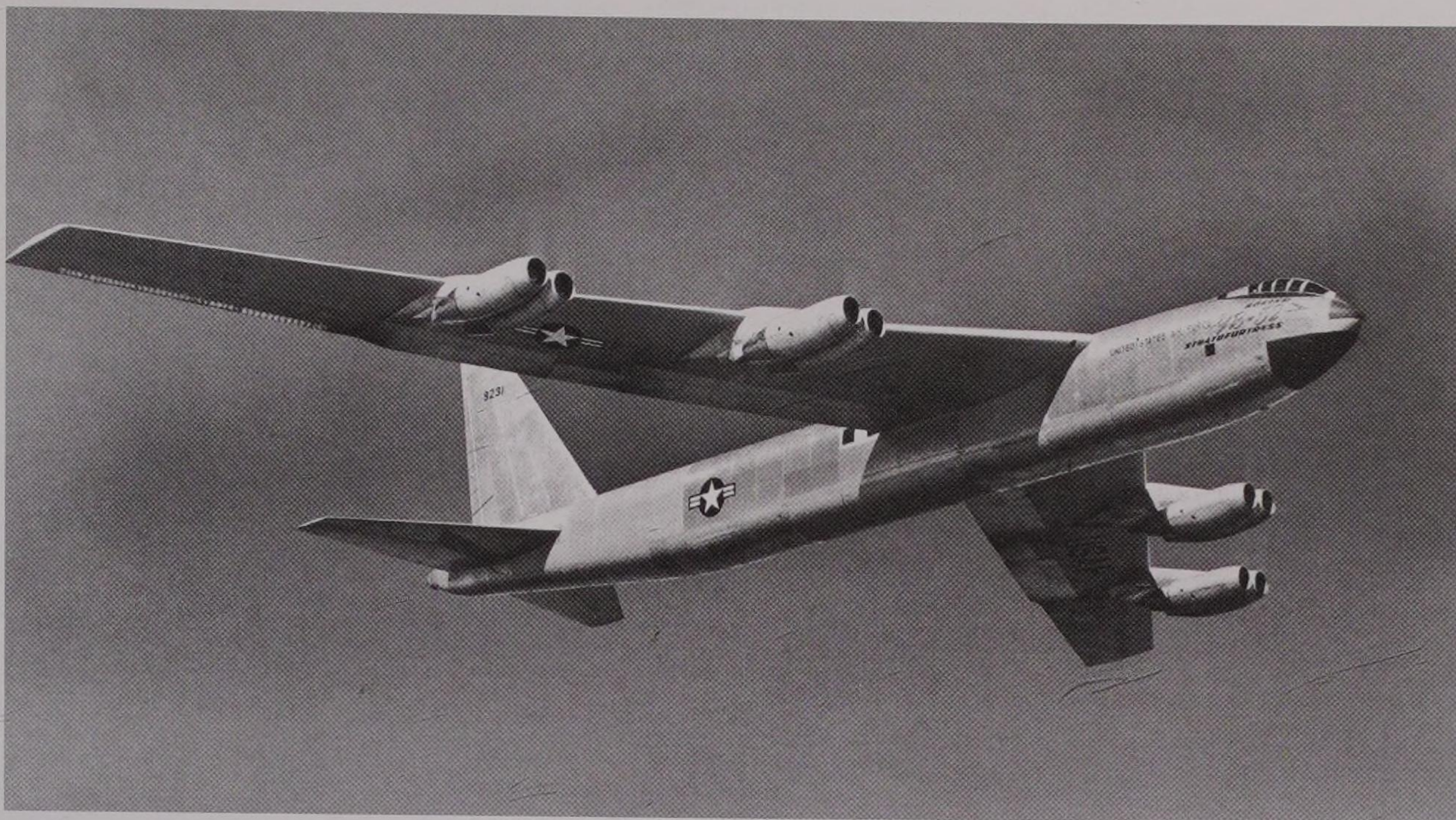
(Greg V. Goebel – www.vectorsite.net)

on 14 February 1951. Then in March 1951 the USAF issued Boeing with a 'letter of intent' for the manufacture of B-52 production tooling. This was all more than 13 months before the aircraft had even undertaken its first flight.

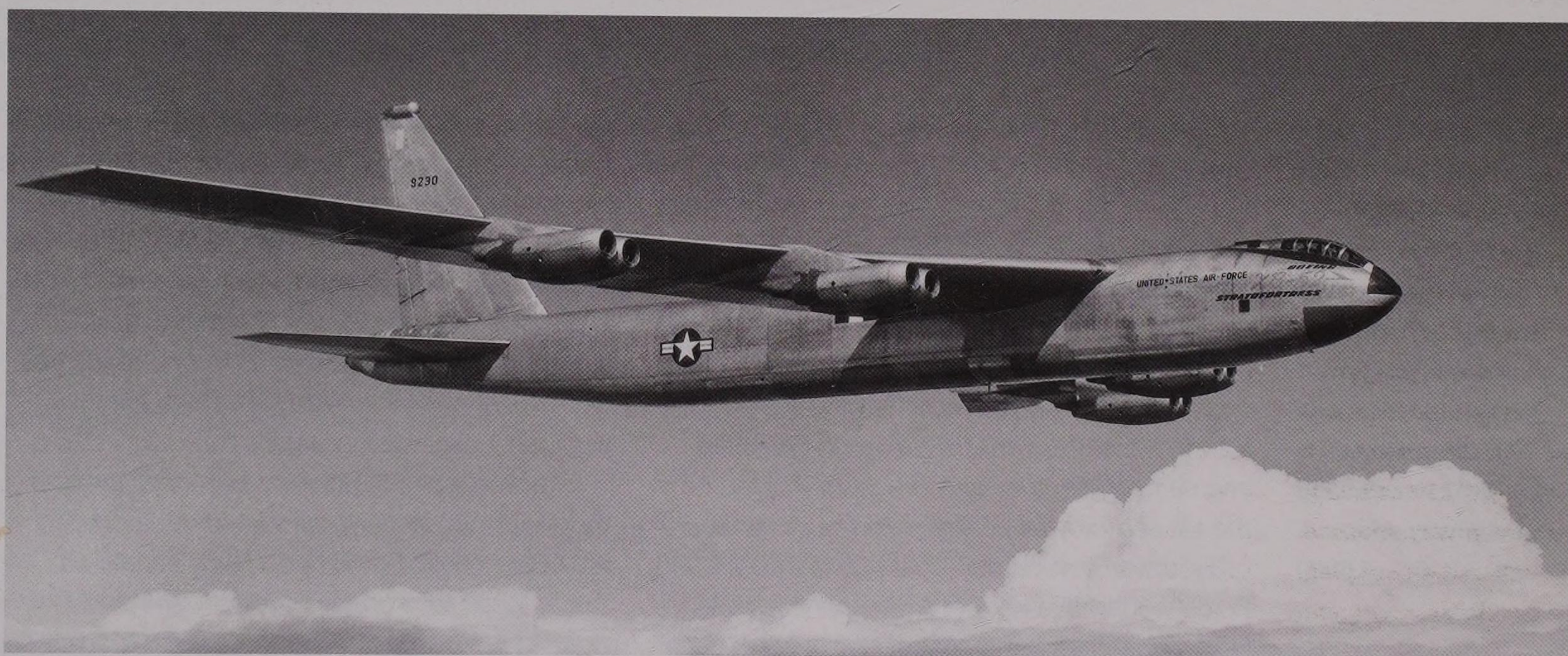
Meanwhile, the two prototypes – the XB-52 and YB-52 – were under construction at Boeing's Plant 2 at Boeing Field, Seattle. The 'Y' prefix indicated the prototype, while 'X' was the identifier applied to the airframe that was to be used for special research. In reality the only difference between the two was that the YB-52 was equipped with flight-test instrumentation to measure airframe flutter. As the aircraft were built, Boeing Field's runway received a 2,500ft extension and a new flight-test hangar was built to accommodate the behemoth bomber.

The YB-52 (serial 49-231) was rolled out on 15 March 1952. One month later to the day it became the first of the two prototypes to fly. 'The pilot for [the YB-52's] first flight was Alvin M. "Tex" Johnston', according to Boeing's official history. 'He became an aviation legend in 1954 when he put the 707 jetliner prototype into a complete 360-degree barrel roll over Lake Washington – not once, but twice during the plane's first public display. The co-pilot was Lt. Col. Guy M.



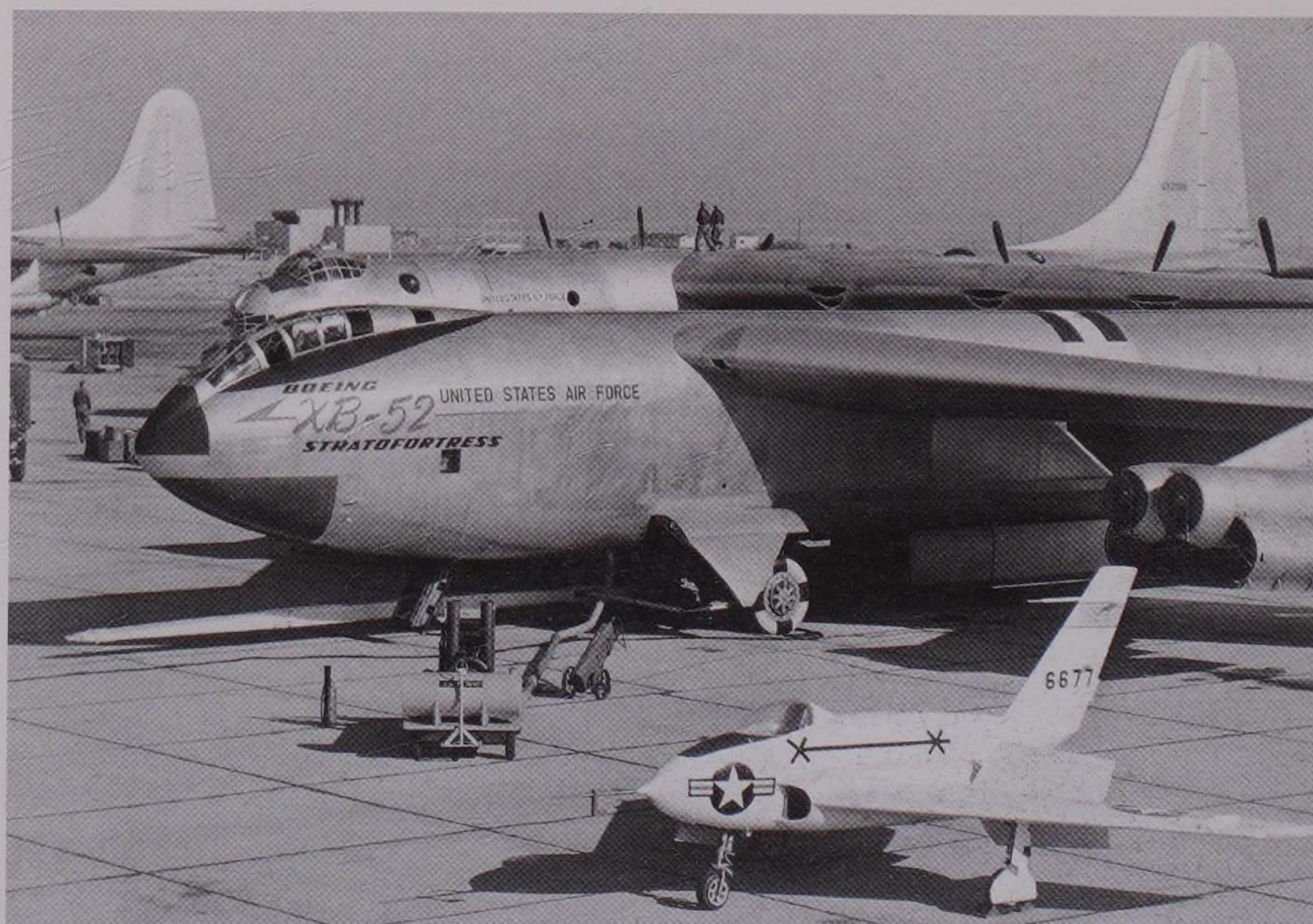


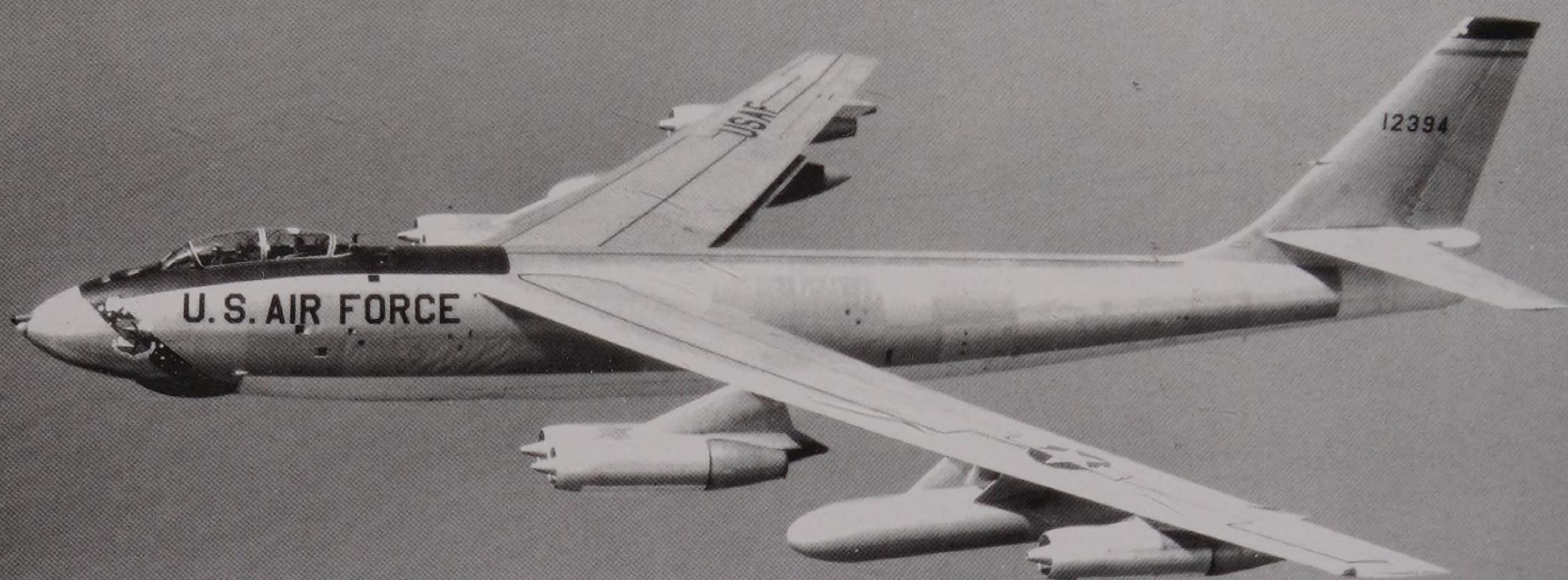
LEFT, BELOW AND BOTTOM The XB-52 flew in October 1952 and was to all intents and purposes identical to the YB-52. On the ground, the XB-52 sits in front of a B-36 Peacemaker and behind a tiny Northrop X-4. Note the black and white calibration markings on the forward fuselage and wheels. (USAF)



Townsend of the US Air Force flight test centre. During World War II, he had flown Boeing B-17s and B-29s. Both pilots had extensive experience with Boeing's first jet bomber, the B-47.'

The 17 April 1952 edition of *Boeing News* described the take-off: 'This was it. The tremendous roar of the engines grew louder and louder as the plane gained speed. It raced down the runway with deceptive speed, past the other bombers that had made history taking off from here: the smaller B-47s, the B-50s, the B-29s and an old but proud B-17, nearly two decades of history-making bombers. The huge crowd that had gathered to watch the takeoff let out a spontaneous cheer.' The XB-52 made its first flight on 2 October 1952.





ABOVE AND BELOW
The similarities between the B-52 and Boeing's B-47 Stratojet design are obvious. These B-47s proudly wear the steel-gloved insignia of Strategic Air Command. The new B-52 would soon be similarly adorned.

(USAF)

One last major design change

The two B-52 prototypes had a tandem seating arrangement, whereby the pilot sat in front of the co-pilot underneath a sleek bubble canopy. In this and other respects the design was similar to that of Boeing's B-47 'Stratojet': a 35° swept wing, pylon-mounted engine nacelles, a brake parachute housed in the tail and bicycle-configuration landing gear.

However, few outside Boeing and the Air Force would have known this before now: the B-52 had, until the moment of its first flight, been

shrouded in absolute secrecy. Aircraft movements between hangars had been made only at night and the two airframes had been covered in tarpaulins in a somewhat comical attempt to hide their overall shape. Indeed, when two aircraft were towed outside the Air Force had, as an additional security measure, closed off roads and highways that overlooked Plant 2 and the new flight test hangar at Boeing Field.

Practical considerations meant that the first flight was necessarily conducted in daylight, although the Air Force had initially stipulated that it take place under cover of darkness! But despite the public viewing there were many innovations that were still worth protecting from prying eyes. Among these was the design of the aircraft's completely moveable horizontal tail – at the time a unique approach to controlling a bomber's pitch attitude. Another was the novel use of four separate and steerable landing-gear units that could be aligned with the runway centreline during a crosswind landing.

The B-52's cockpit layout was also considered sensitive. LeMay, now the Commander of Strategic Air Command (the USAF's nuclear deterrent force), had stipulated in 1951 that he wanted the production B-52 to feature side-by-side seating. This, he said, facilitated better crew coordination and offered a better ergonomic arrangement of the aircraft's instrumentation and cockpit controls. It was far





too late to modify the XB-52 and YB-52, but the B-52A would feature this one final major change from the Model 464 design. The interior configuration of the newly designed crew cabin layout would also remain secret for some time.

Production and introduction into service

In June 1952, just two months after the YB-52's first flight, the Air Force amended its 1951 order of 13 B-52As, despite the first example being more than two years away from its first flight. It now wanted only three B-52As, which would immediately be handed over to Boeing, and ten of the higher specification B-52Bs (see Appendix 1 for a full production list and annual delivery schedule). The B-52A embarked on its maiden flight on 5 August 1954, and as per the Air Force's wishes the first three examples were immediately used by Boeing for flight test purposes and development of the forthcoming B-52B.

ABOVE The date is 5 August 1954, and Boeing's B-52A – 'the first production model in a new series of long range bombers' – takes off from Boeing Field, Washington, on its maiden flight. Powered by eight Pratt & Whitney Aircraft J-57 turbojet engines, each rated in the 10,000lb of thrust class, the aircraft had a wing span of 185ft, length of 156ft, tail height of 48ft, and gross weight of more than 350,000lb. (USAF)

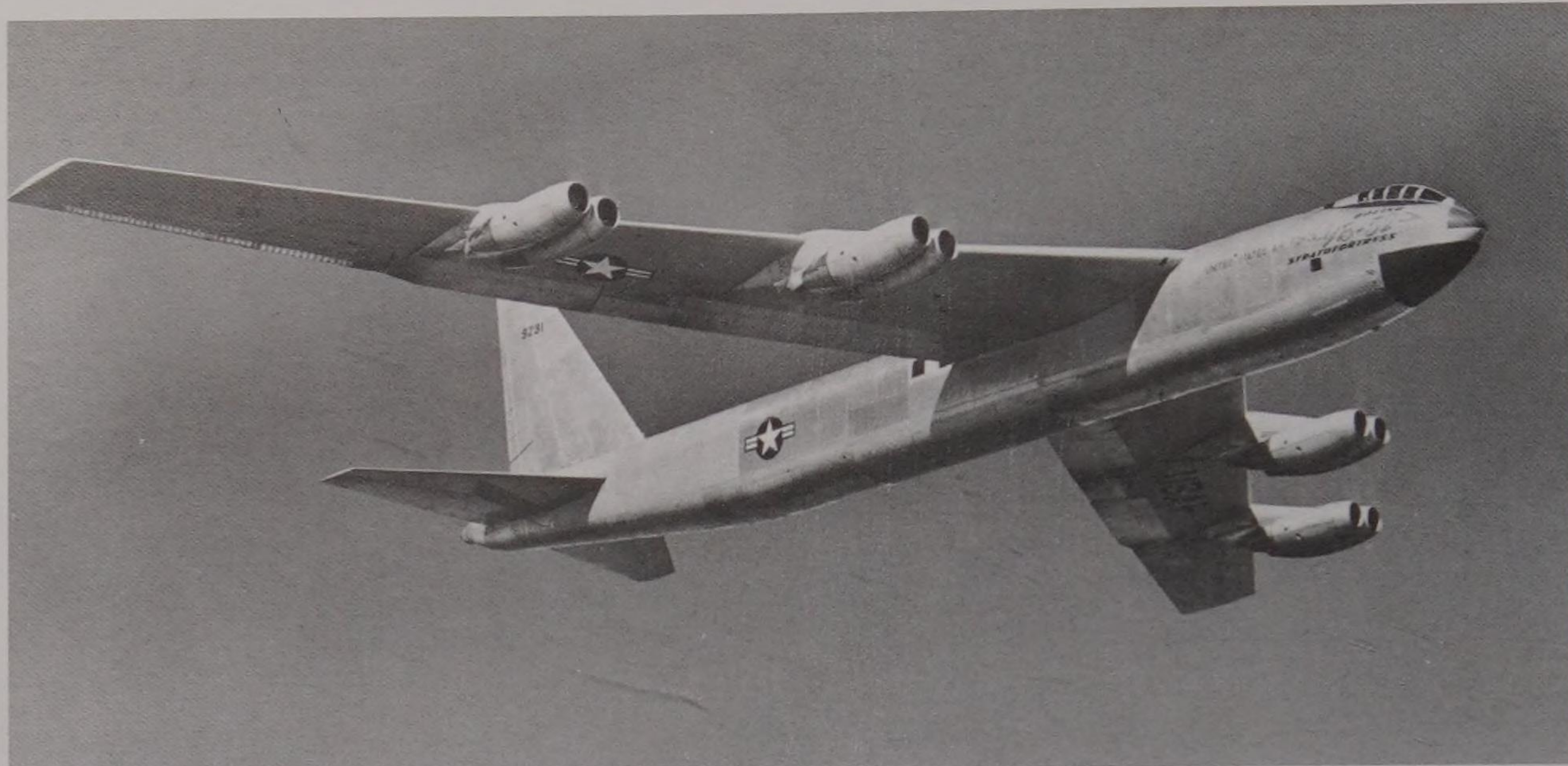
The B model had been in development since 1951 and was powered by eight Pratt & Whitney J57 axial flow turbojet engines. It incorporated some minor avionics and airframe updates, and also added an improved water injection system for take-off that produced an



RIGHT Brigadier General William Eubank (right), the 93d Bomb Wing commander, talks with Air Force officials on the flight line at Castle AFB, California, following delivery of the first operational Stratofortress – a B-52B – on 29 June 1955. (USAF)

RIGHT AND BELOW
While flight testing of the B-52A and B-52B continued, the XB- and YB-52s had been put through their paces.

Here the YB-52 is photographed landing on Rogers Dry Lake, California, in 1953.
(USAF)



BELOW A fatal accident in 1956, in which the entire crew was killed, resulted in the Air Force rejecting the first 31 B-52Bs delivered to it by Boeing. As seen here, the B-52B wore a natural metal finish, with white anti-flash coatings on the underside and engine pods. (USAF)



additional 12,000lb of thrust. It became the first B-52 to actually enter USAF service when SAC's 93d Heavy Bombardment Wing (HBW) took delivery of its first example, serial 52-8711, at Castle Air Force Base (AFB), California, on 29 June 1955. For each B-52 delivered, the Wing shed one of its B-36 Peacemakers, and Castle AFB's ramp was soon occupied by a mix of the old and the new.

The 'Stratofortress', as it was officially named by the Air Force (or 'BUFF'*, as it soon became known amongst USAF personnel), had anything but a smooth introduction into service, however. Two were lost to mishaps within the space of a year, and the consequent groundings that followed while investigations were under way

* Various interpretations as 'Big Ugly Fat Fellow', 'Big Ugly Flying Fellow' and 'Big Ugly Fat F****r'.



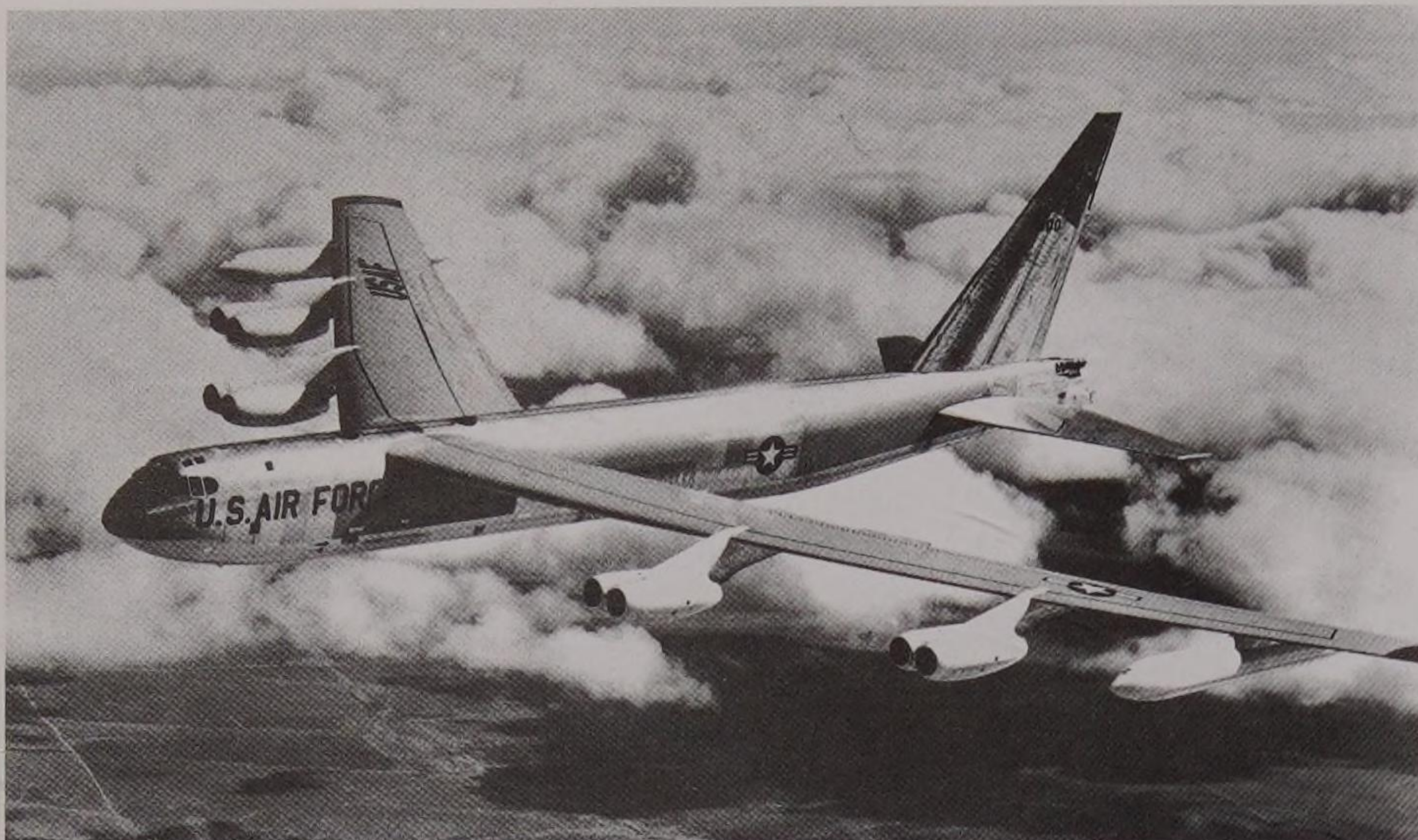
cost the 93d HBW valuable time in working up to operational capability. The cause of the first mishap, which cost the lives of the whole crew, was traced to a faulty flywheel in an alternator. The wheel, spinning rapidly and with massive momentum had (presumably) separated from its mount, punctured a fuel tank and caused the B-52 to explode in mid-air. The incident resulted in the Air Force rejecting 31 of the first 78 B-52Bs delivered by Boeing until the alternator design deficiency had been corrected.

Beyond the fatal mishaps, numerous other problems abounded. The J57 engine, derived from the XT45 turboprop engine that had once been destined to power the XB-52, may well have been the first 10,000lb class turbojet the United States had produced, but it was still nascent. It was troublesome to operate and

maintain. In addition, the aircraft's fuel system was prone to leaks and icing problems. The Air Force responded by assembling a team of 50 contractors who worked alongside its own engineers and maintainers to keep the young fleet airworthy. Dubbed 'Sky Speed', these contractors provided expert knowledge and advice. Yet despite Sky Speed's acumen and know-how, a single B-52 could still consume a week's worth of labour before it could undertake its next flight.

Things were not all bad, though. In March 1956 the first B-52C took to the skies, with deliveries to the Air Force of this extended-range model following in June the same year. The arrival of the white-bellied C model had been preceded on 21 May by the B-52's first live H-bomb drop: a four-Megaton Mk15

ABOVE The B-52B cockpit was nearly identical to that of the B-52A, and little would change in the layout until the introduction of the B-52D and, more significantly, the B-52G. This image shows NASA's B-52B cockpit as it was in 1996. (NASA)



ABOVE With 3,000-gallon wing tanks impossible to miss, the B-52C was readily recognisable when it took to the skies in March 1956.

Also noteworthy, and just visible in this image, is the black radome for the weather radar in the nose. (USAF)

RIGHT AND OPPOSITE PAGE

During the Cold War, and for many years afterwards, the B-52 was an integral part of the Single Integrated Operational Plan (SIOP). Over the years the weapons and the variants changed – from B-52Ds equipped with Hound Dog missiles (near right), to B-52Gs and Hs equipped with B-61 free-fall nuclear bombs (middle) and AGM-86 ALCMs (far right). Whatever the combination, the deterrent never wavered. (USAF)

'Zombie' bomb. The event, codenamed 'Cherokee', occurred over Bikini Atoll in the Pacific Ocean.

Other achievements followed. As part of 'Operation Quick Kick', the B-52 set the first of many records to follow when four 93d BW aircraft and four B-52Cs of the 42d Bomb Wing completed a 16,000-mile non-stop flight around the circumference of North America in 31 hours and 30 minutes. This 25 November 1965 flight 'required four in-flight refuellings and included a pass over the North Pole', said Boeing, while SAC commented that the time could have been shortened by the order of as much as six hours had jet-powered air refuellers been available. The venerable prop-

driven Boeing KC-97 'Stratotankers' had slowed the B-52s down!

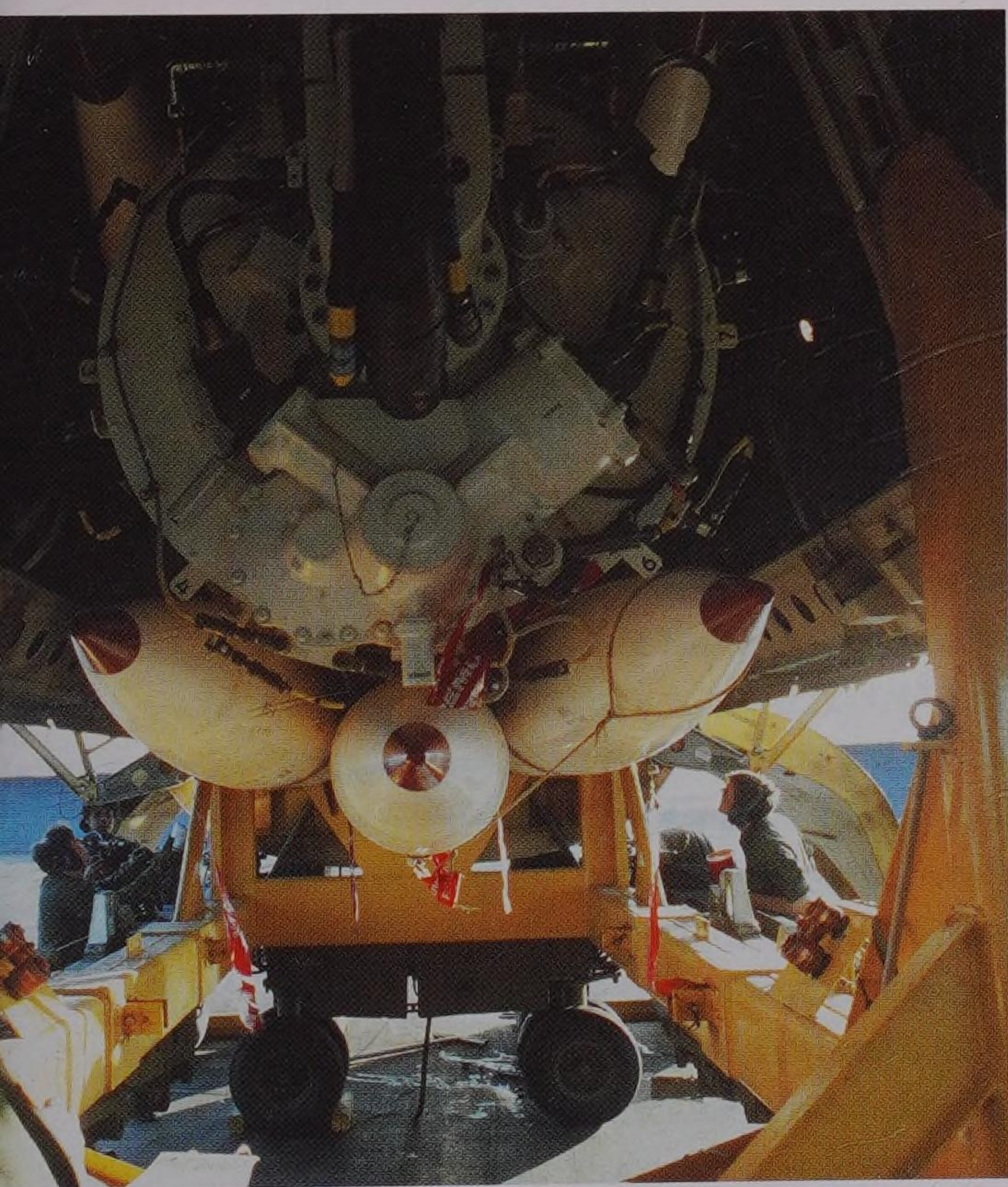
While most B-52Bs functioned as conventional or nuclear bombers, 27 of the 50 built were capable of carrying a photoreconnaissance or electronic intelligence (ELINT) pod in the bomb bay. These were designated RB-52Bs, and could be configured from the bomber role to the recce role in a matter of four hours.

Cherokee had been a truly significant moment because, in tandem with the 93d HBW declaring initial operating capability two months earlier in March, it demonstrated that the *raison d'être* for the B-52 could now be fulfilled. The B-52 provided the President of the United States with another powerful nuclear tool with which to counter the increasing threat from a substantial Soviet military.

The event also signalled that the B-52 was ready to become an integral part of the so-called SIOP, or Single Integrated Operational Plan. SIOP began in 1961 and integrated the nuclear forces of the US Navy and the USAF: submarine-launched ballistic missiles, ICBMs (intercontinental ballistic missiles) and air-launched nuclear weapons.

For the B-52, this meant sitting 'cocked' on nuclear alert – cockpit switches in position to enable a quick scramble at a moment's notice





to strike targets in the Soviet Union, should the Presidential order be given to do so. Similarly, it also meant flying airborne 'Chrome Dome' alert missions, sometimes lasting as long as 26 hours, whereby Stratofortresses loaded with nuclear weapons were airborne and ready to strike. Chrome Dome missions were conducted at high altitude; whilst they remained in international airspace, they flew close enough to the Soviet Union that their retaliatory strikes could occur that much faster.

The B-52 family grows

As the 1950s wore on, so the B-52 family grew. 'Project Sunflower' resulted in seven B-52Bs being retrofitted to B-52C standard, and then the D model arrived in late 1956. It offered similar capabilities to the C model, and is perhaps best known for the conventional carpet bombing missions – known as 'Arc Light' sorties – that it undertook during the conflict in Vietnam. The arrival of the D model prompted 'super' Bombardment Wings of B-52s to be split into three smaller squadrons of 15 aircraft apiece. These squadrons, each accompanied by a support squadron of 10 to 15 air refuellers, were then dispersed across numerous Air Force sites. The move made Russia's strategic missile targeting of the SAC bomber force a more complex affair, mitigating against the risk that the force could be wiped out in a single pre-emptive nuclear strike.

Next came the B-52E in 1957, and then the re-engined B-52F. The latter would soon

become the first Stratofortress model to drop a bomb in anger (over South Vietnam, June 1965). At this juncture it was clear that the high-altitude, high-speed ingress routes envisioned for SIOP were becoming less and less tactically sound – Russia was developing and fielding a capable and dense array of surface-to-air missile (SAM) sites around key strategic, political and military targets, and the B-52 was simply not designed to fly through what amounted to an increasingly intimidating thicket of 'threat rings'.

When Francis 'Gary' Powers was shot down in his high-altitude Lockheed U-2 'spy plane' in 1960, SAC leadership ordered a switch in tactics – the B-52 force would now ingress their SIOP targets at very low level. By flying low, the pilots could 'mask' the presence of their aircraft from the sweeping search, acquisition and targeting radars of Russia's SAM batteries by flying below rising terrain en route to the target.

The switch was not inherently beyond the capabilities of the B-52, but initial training for these new penetration techniques resulted in two fatal mishaps. Both occurred at low level when the tall vertical stabiliser of the Stratofortress snapped off as the aircraft crossed mountainous terrain. It was quickly established that turbulent low-level air had overstressed the vertical tails. These hostile flight conditions were also causing accelerated structural fatigue in the B-52s' tail sections and wings.

By this point a redesign of the B-52 was already nearing completion. The B-52G had flown in 1958 and entered service in 1959, one day after the B-36 Peacemaker was formally retired. Meanwhile, the H model would take to the skies in March 1961 and be delivered to the Air Force two months later. The G model was intended to be a stopgap measure that would stay in service for as long as was required to introduce the Air Force's newest bomber, the supersonic Convair B-58 'Hustler'. However, the Air Force was indecisive about the Hustler programme and LeMay, still governing SAC with an iron fist, insisted that B-52 production continued despite believing that the Hustler would succeed. As Operation Linebacker II progressed in South-East Asia, this new model was deployed to complement the B-52Ds still flying missions deep into North Vietnam.

The H model, the last-ever B-52, was

BELOW The B-52G was the penultimate marque of Stratofortress and was originally intended to serve as a stopgap until the B-52H entered service. This B-52G, with 20mm Vulcan tail gun, lowers its undercarriage in preparation to land. (USAF)



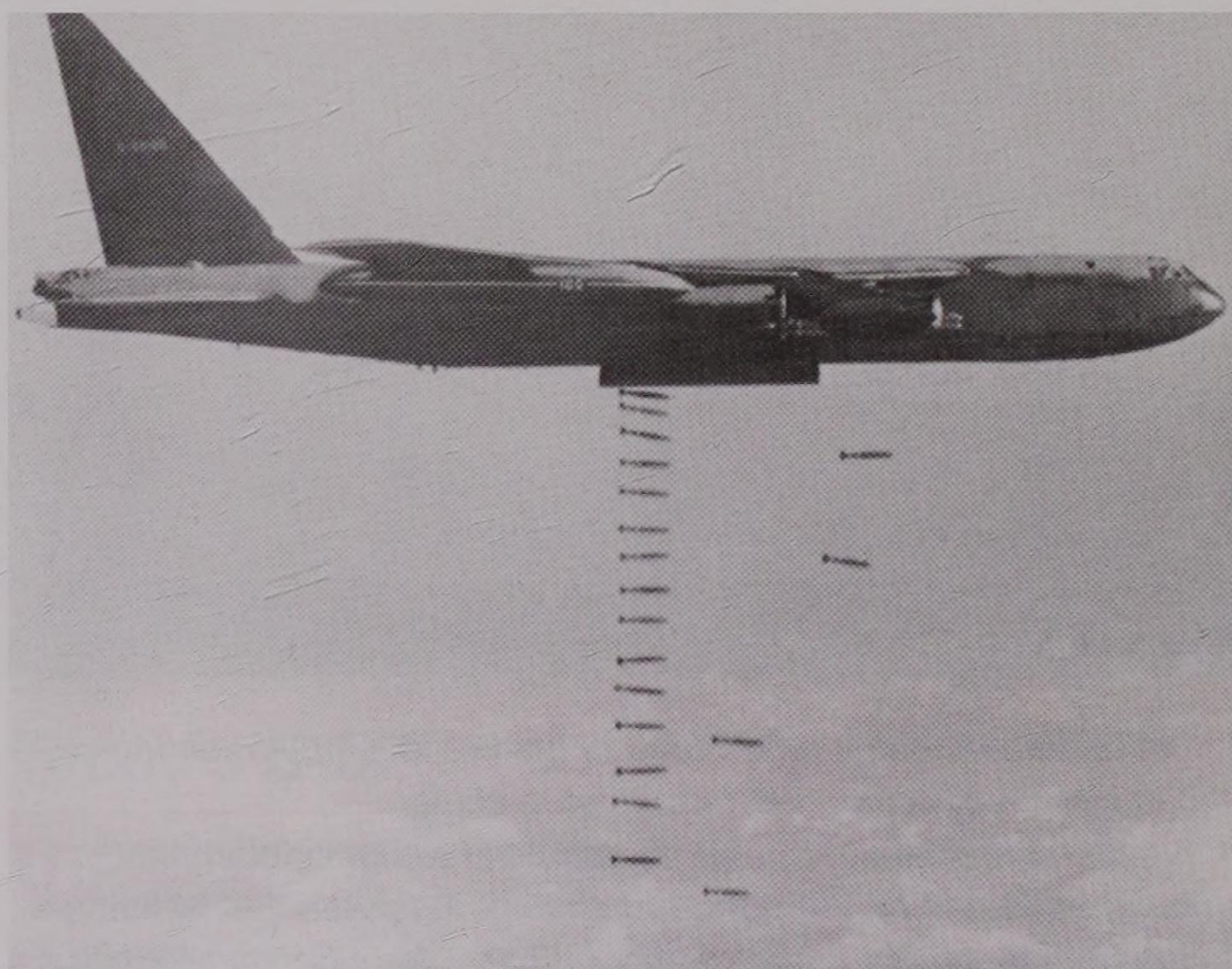
RIGHT A B-52H, today the sole operational B-52 type in service, takes off with characteristic nonchalance. The flex of the aircraft's long wings is evident in this image. (USAF)



similarly 'lucky' to be built, since Air Force leaders were fully expecting the triple supersonic XB-70 'Valkyrie' – whose Mach 3 speed would allow it to enter the Soviet Union's threat rings with much greater survivability – to enter service in short order. As it was, the Valkyrie flight test programme ended in 1966, the same year as the B-52B was being phased out of service. By that time the US Defence Secretary, Robert McNamara, had already decided that the B-70 would be unjustifiably expensive. So NASA took control of the XB-70 test programme, and the B-52H was built after all.

The two new Stratofortress variants featured a 'wet wing' that had integral fuel tanks, newer engines, a revised cabin configuration and other significant differences that gave them extra range and capability. But despite having smaller vertical stabilisers, the Air Force assessed correctly that the aerodynamic stresses of low-level ingress could have equally catastrophic effects on these new models too.

While actual combat in the skies over Vietnam was showing the Stratofortress to be an effective conventional bomber, the continuing toll from low-level penetration training in the United States was being felt by the US-based B-52s. The fatigue life of the new variants was of particular concern, for whilst the B, C, D, E and F variants of the B-52 would be retired



CENTRE While B-52Ds like the one pictured were flying Linebacker II missions over North Vietnam, the Air Force was still unsure about the Convair B-58 Hustler... (USAF)

RIGHT ... because the Hustler (pictured here in 1967) was causing SAC commander General C. LeMay much consternation. It would eventually enter service, but its career was comparatively short-lived at only nine years. Ultimately, the 'stopgap' B-52G was superseded not by a slick, supersonic bomber, but by a distinctly subsonic younger brother: the B-52H. (USAF)





ABOVE Shown dropping a stick of 750lb slick bombs over North Vietnam in 1966, this B-52F was operating out of Guam. Noteworthy is the change in camouflage from an anti-flash white to gloss black underside – a practical necessity given the move from strategic nuclear alert to tactical strikes by night and day. (USAF)

soon enough, the G and H would need to serve for many years to come.

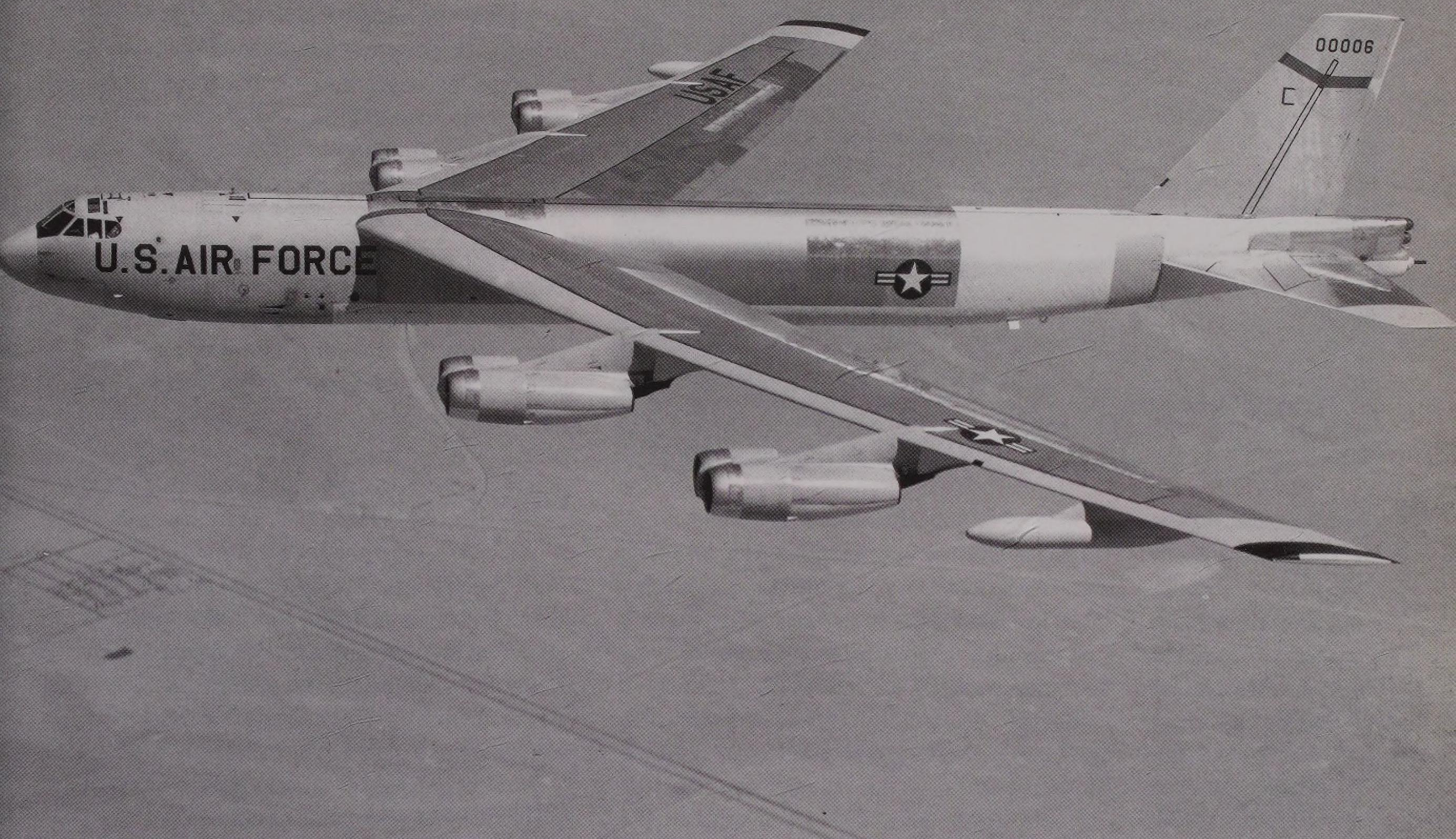
This all resulted in a number of significant Engineering Change Proposals (ECPs) that ran back-to-back. ECP 1050, which strengthened the (heavier) wet wings of B-52Gs and B-52Hs, was completed in 1964; ECP 1185 was initiated in May 1966 and replaced G and H model fuselage side skin, crown skin fasteners and upper longerons; ECP 1128 resulted in the replacement by 1966 of the vertical stabiliser spars on all B-52s, regardless of variant; ECP 1124-2 reinforced the tail section in general; and ECP 1195, which became known as the B-52 Stability Augmentation and Flight Control programme, updated the flight control system to further alleviate the effects of gusting winds and turbulence, and was implemented by the end of the decade.

With the B-52H and G 'beefed up' and entering service in great numbers (there were 175 B-52Gs operational in 1975), the two new

Stratofortresses were subject to a series of 'modernisation programmes'. These included the installation of an electro-optical viewing system (EVS) that consisted of low-light and infrared cameras, the installation of 'Rivet Ace' Phase VI ECM equipment, and the installation of improved offensive avionics.

Of course, this all meant the beginning of the end for the older B-52 marques. The Air Force's C and E models were gradually phased out of service during the early 1970s, followed by the war-weary B-52Fs in the late 1970s and the B-52D in 1983.

In 1991 the B-52 returned to war, with G and H models deployed to Saudi Arabia as part of the effort to oust the invading forces of Iraq from its tiny neighbour, Kuwait. However, in the following year the United States and Russia reached agreement on the Strategic Arms Reduction Treaty, part of which called for the destruction of an agreed number of nuclear-capable bombers.



The Strategic Arms Limitations Treaties (SALT) of the 1980s resulted in the United States agreeing to clearly identify its AGM-86B nuclear air-launched cruise missile (ALCM) bombers. While the H model was readily identifiable by its unique engines and associated nacelles, only 98 G models had been modified to carry these weapons, and there needed to be some way to identify them. The solution was to fit 'strakes' – leading-edge wing root extensions – that allowed Russian observers and satellites to count and track them. Eventually non-functioning 'elephant ear' antennae were also bolted on to the rear fuselage of ALCM-capable B-52Gs as an additional recognition aid.

Now, with the fall of the Soviet Union, America agreed to destroy 365 B-52s as part of the Strategic Arms Reduction Treaty. The B-52G, the most numerous Stratofortress ever, was quickly retired and all but a handful were destroyed in compliance with the treaty.

Today's B-52

With the B-52G gone, the H model became the focus of a number of upgrades as the 1990s wore on. First amongst these was the May 1994 'Rapid Eight' upgrade that would give the bomber a guided missile capability. Crucially, 1994 also saw the start of the Conventional Enhancement Modification programme (CEM). CEM would offer support for precision guided weapons for use against fixed targets on the battlefield, and involved the installation of a global positioning system under ECP 0109. The same ECP also provided for the installation of an integrated conventional stores management system (ICSMS) that improved the aircraft's attack capabilities.

CEM/ICSMS resulted in the joint direct attack munition (JDAM) being cleared for use in December 1998, and the wind corrected munitions dispenser (WCMD) – an INS guidance kit for cluster bombs – being cleared for use

ABOVE The B-52H Stratofortress underwent test and development at Edwards AFB, California, during the early 1960s. This image, showing serial 00006, dates back to that decade. Note the much shorter tail fin in comparison to all marques prior to the B-52G. (USAF)



ABOVE A KC-10A Extender lowers its refuelling boom for an approaching B-52H over the Gulf in 2003. The installation of the CEM/ICSMS packages has given the H-model a precision strike capability much valued by ground forces. This example carries 12 GBU-31 JDAMs on wing-mounted HSABs. It is likely that the munitions were expended over Afghanistan shortly after this photograph was taken. (USAF)

RIGHT B-52A serial number 52-001 in flight with tip tanks removed. The A-model B-52 demonstrated a maximum take-off weight of 415,000lb. (USAF)

in June 1999. Earlier that year the B-52H had once again been in combat, firing the first salvo in NATO's (the North Atlantic Treaty Organisation) operation against the former Republic of Yugoslavia. In fact, the B-52 had spent much of the 1990s flying combat missions to help enforce the No-Fly Zones that had been established over Iraq following the 1991 Gulf War.

In December 1999, and following the completion of the CEM programme, the US Air Force initiated the B-52H Avionics Midlife

Improvement (AMI) programme. This extensively modernised the aircraft's offensive avionics system's processors and navigation systems, further harnessing its precision strike capability.

The AMI upgrade was fortuitous in its timing. Less than two years later, the US and its allies took military action to remove the infamous Taliban from power in Afghanistan, as part of the global war on terror. Here, and over Iraq once more from March 2003, the precision capabilities of the B-52 would be vital for the support of US and Coalition ground troops.

In 2003 SIOP was replaced by the nuclear attack plans 'OPLAN 8044' and then 'OPLAN 8010'. Operating under these, the Stratofortress continues to remain on nuclear alert in 2012.

Variant summaries

B-52A

The first production B-52 was equipped with J67-P-1W engines, a tail turret in which four .50 calibre Browning M3 guns (and 600 rounds of ammunition each) were mounted, and 360 gallons of water carried in a rear fuselage tank for water-injected take-offs. It had a total internal fuel capacity of 35,600 gallons carried in fuel bladders in the wing and on top of the fuselage, supplemented by two 1,000-gallon auxiliary fuel tanks beneath each wing.



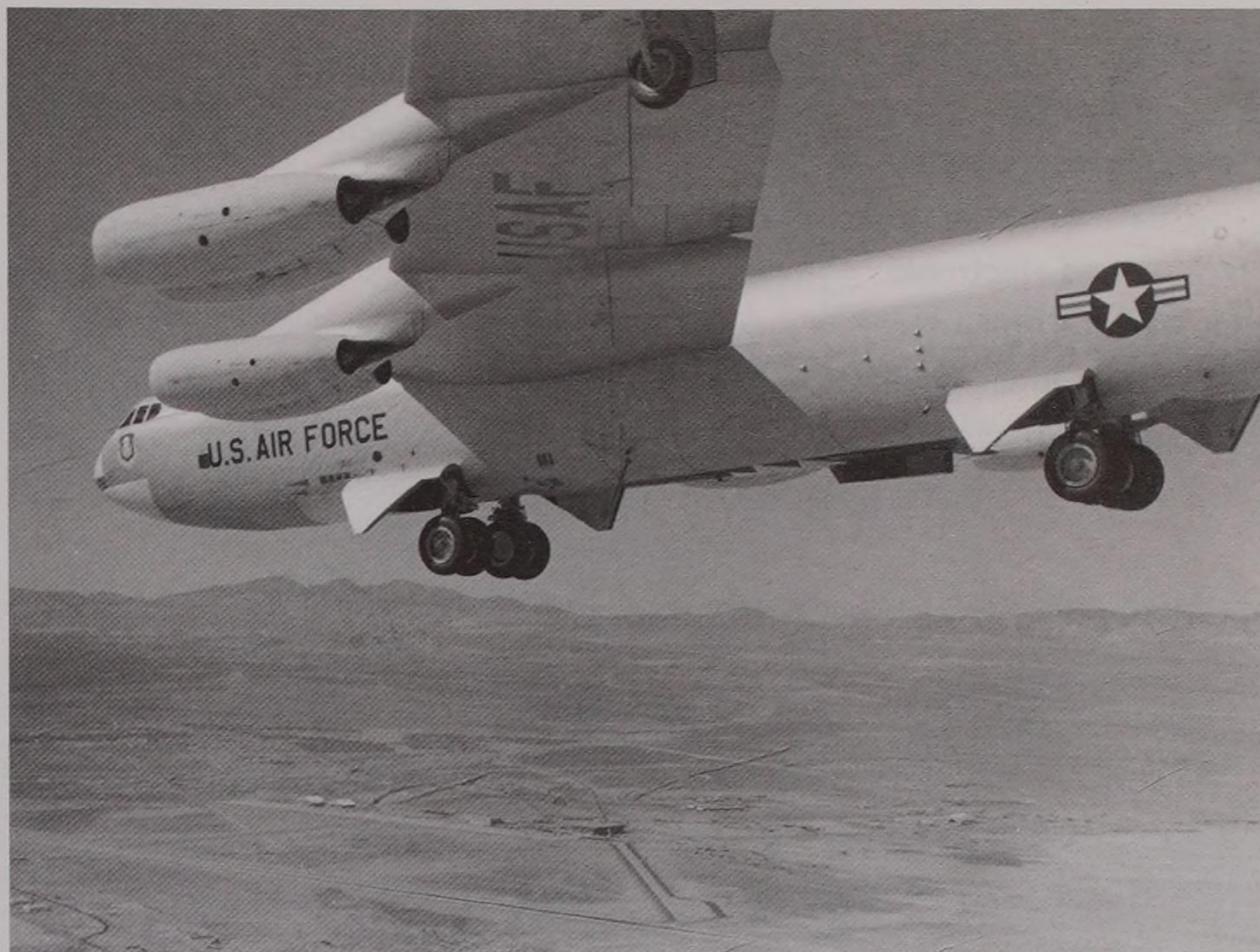
In contrast to the XB- and YB-52s, the B-52A crew compartment was characterised by a split-level arrangement, with the upper deck featuring upward-firing ejection seats for the pilot, co-pilot, navigator and radar navigator. The lower deck had two downward-firing seats, one for the electronic warfare officer and the second for an instructor or relief crew member.

The aerial gunner sat in the pressurised tail cone and operated the four M3s by means of the A-3A defensive fire control system (DFCS). The A-3A employed two radars – one search and one tracking – to automatically ‘lead’ the target, but also featured an optical sight for manual targeting. The gunner could jettison the entire tail cone in order to bail out of the aircraft (or for emergency ground egress), and could access the main crew compartment from the tail section by means of an unpressurised ‘crawlway’ that linked the two.

The aircraft had a placarded maximum gross weight of 405,000lb, although the last flights undertaken by the three Air Force A models in 1960 demonstrated an actual ability to take off at 415,000lb all-up weight.

B-52B

The B-52B increased the original gross weight limit to 420,000lb. Almost half of the B-52Bs built were fitted with the same P-1Ws as the



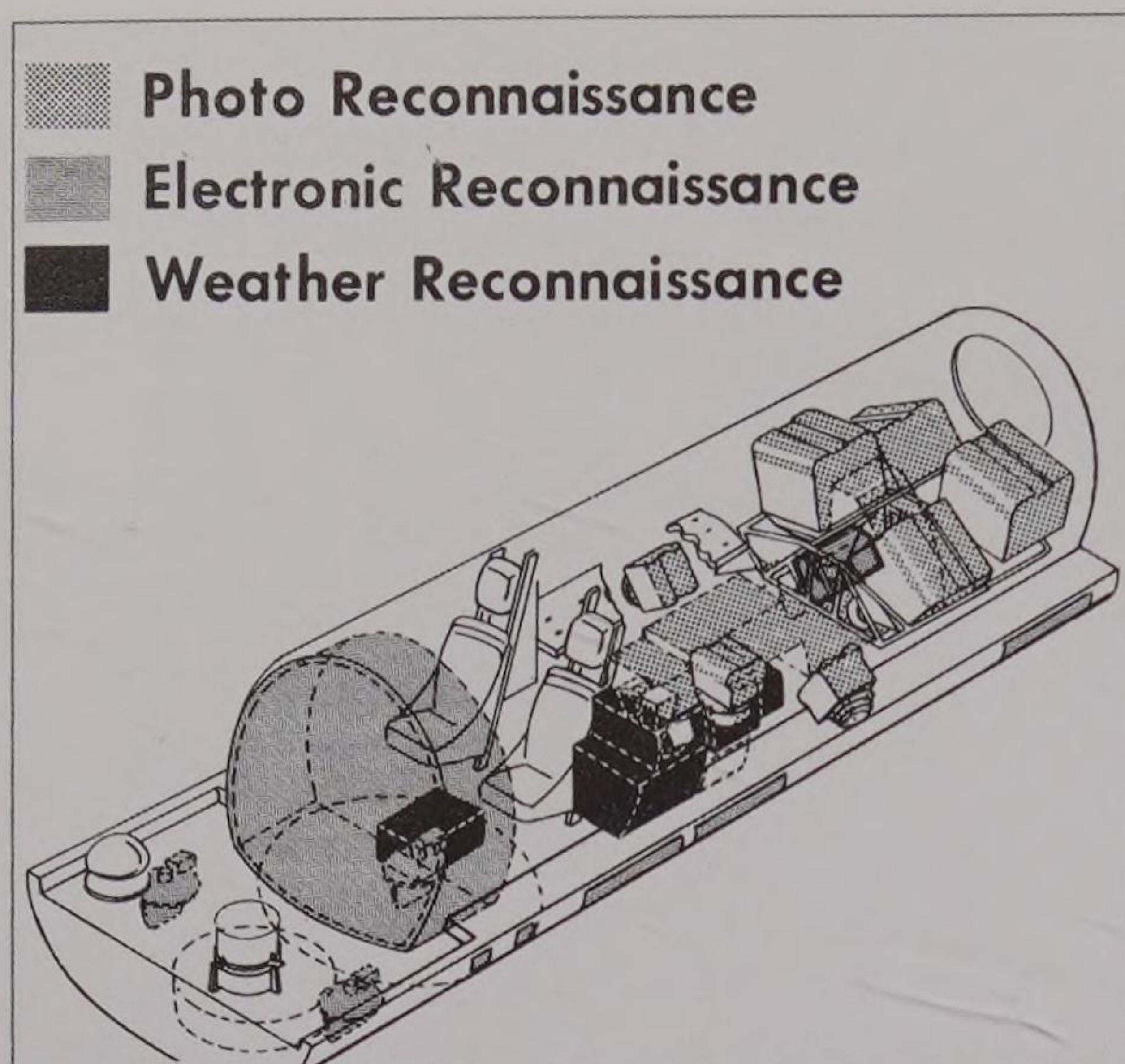
B-52A. However, J57-P-29W32 and J57-P-29WA engines were installed on all but five of the remaining B-52Bs. The difference between the two newer engines was that the rate of water injection in the P-29W32 engine was half that of the P-29WA, making the latter the more desirable option. The remaining five B-52Bs were equipped with the P-19W, a variant of the J57 that used titanium components that saved weight and offered 10,500lb of thrust.

Fifty B-52Bs were built to fulfil a secondary reconnaissance role – making them RB-52Bs

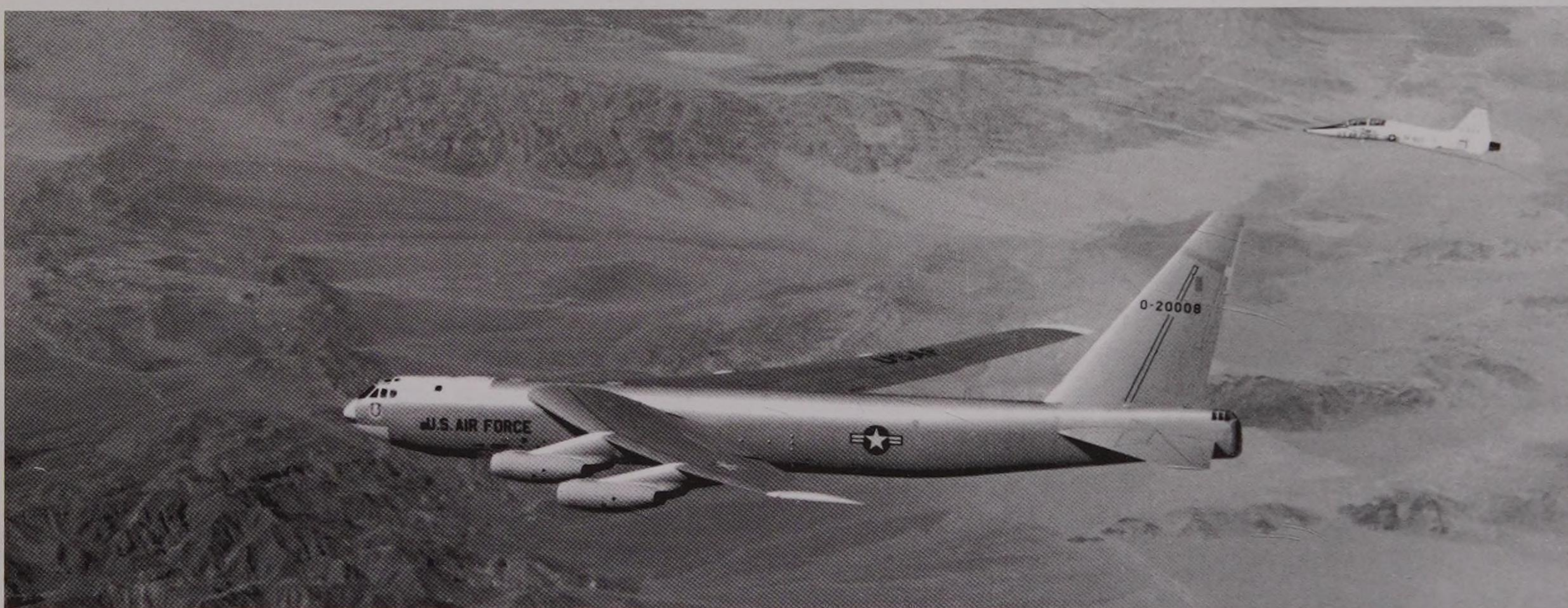
ABOVE AND BELOW
The first B-52B on approach to land and in flight. This marque of Stratofortress increased the original gross weight limit to 420,000lb. (USAF)



RIGHT The RB-52B reconnaissance capsule incorporated elements for photo and electronic intelligence gathering in addition to weather observation. (USAF)



– and were therefore capable of carrying a dedicated recce pod in the bomb bay. Originally referred to as the RX-16 system in reference to its post-war roots, the multipurpose pod covered RF and visual spectrums. An AN/APR-14 low-frequency radar receiver, two AN/APR-9 high-frequency radar receivers, two AN/APA-11A pulse analysers, three AN/ARR-88 panoramic receivers and an AN/ANQ-1A wire recorder, on which to capture all of the mission data, covered the RF spectrum. Four K-38 cameras, one T-11 or K-36 terrain camera and three T-11 cartographic mapping cameras covered the visual spectrum. Weighing only



ABOVE AND RIGHT Boeing RB-52B in flight and on the ground. In the lower image, the three closest aircraft with visible tail numbers are B-52B (S/N 53-0396), RB-52B (S/N 53-0377) and B-52B (S/N 53-0391). (USAF)



300lb, the pod was winched in and out of the bomb bay, taking less than four hours to install or remove.

All B-models were equipped with the MA-6A bombing navigation system. Nine of the first ten RB-52Bs were fitted with the .50 calibre turret and the A-3A DFCS, but 18 RB-52Bs and 16 B-52Bs were fitted with the MD-5 DFCS, which incorporated a pair of M24A-1 20mm cannons. Although impressive on paper, the MD-5/20mm combination offered little real improvement, so the final seven B-52Bs were built with the A-3A/.50 calibre gun turret.

The aircraft featured an MA-2 bomb director bombing system, comprising an optical bombsight, a target radar scope and an automatic computer. This was an archaic system that linked with the B-52's nose-mounted targeting radar, but despite being the best system available it was not deemed suitable for the job at hand.

This was the first B-52 to be cleared to employ hydrogen bombs, namely the Mk15 'Zombie'.

B-52C

The C model once more saw an increase in maximum gross weight, this time raising the figure to 450,000lb, but also extended the aircraft's unrefuelled range through an increase in total fuel capacity to 41,700 gallons (thanks

in part to larger auxiliary fuel tanks). Like the B model, the aircraft was fitted with P-19W or P-29WA engines.

Initially built with the A-3A DFCS, a retrofit programme saw the replacement of this system with the new MD-9, which continued to steer the original turret consisting of four Browning M3s, and which would become the standard DFCS on all future models up until the B-52G.

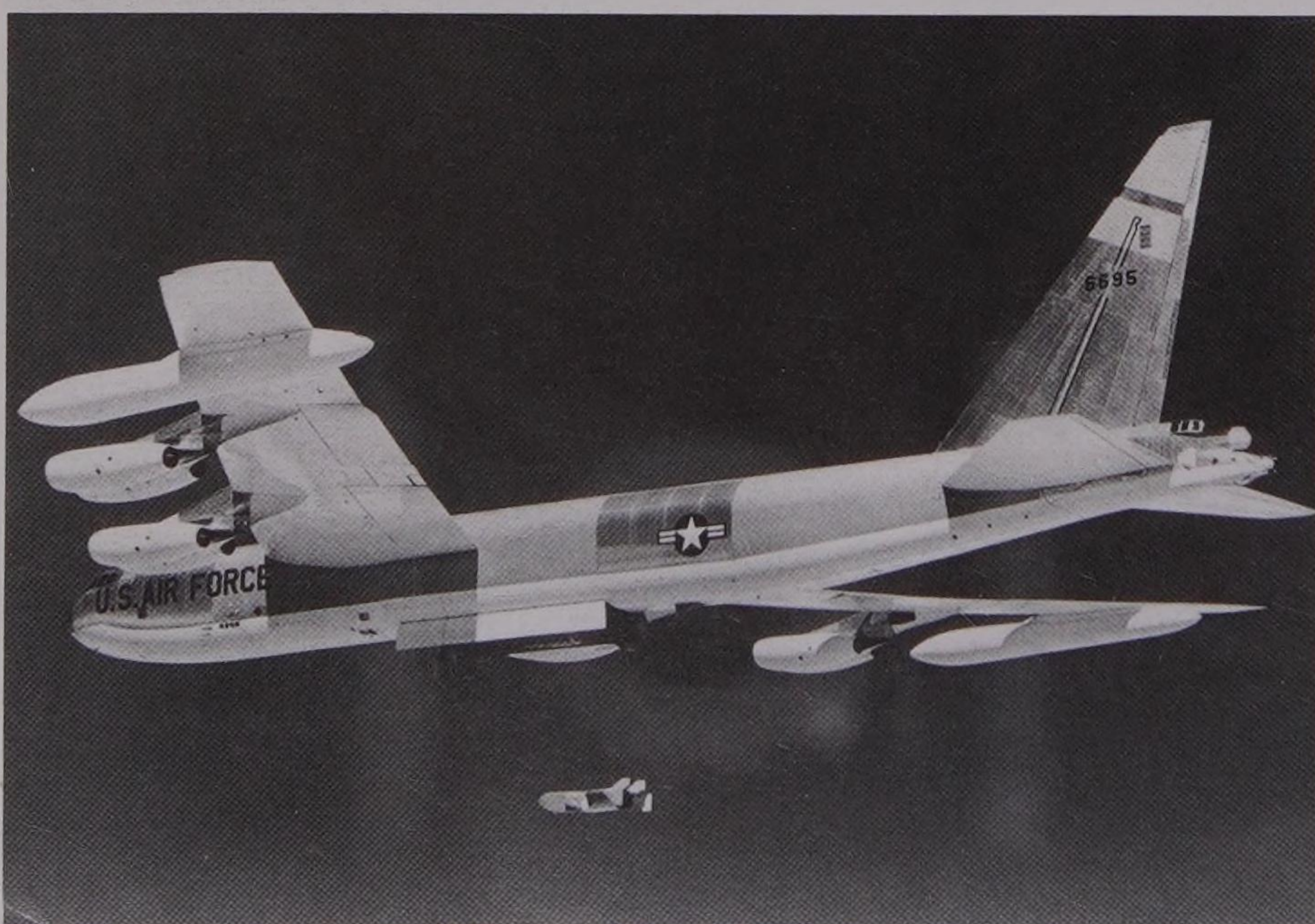
The B-36 Peacemaker's K-3A bombing system had been fitted to some B-52Bs, but above 35,000ft it had such poor resolution that the target was impossible to identify, rendering it unable to accurately drop its 24,000lb bomb load. The B-52C initially made use of an amplifier that boosted the aircraft's radar by 50%, but this was eventually replaced by the 'improved' MA-6A bombing-navigation system. Even the 'vastly improved' AN/ASB-15 bombing system proved lacklustre, so most B-52Cs were eventually retrofitted with an AN/ASQ-48 bombing-navigation system that gave the aircraft the ability to cue air-to-surface missiles to the target.

All B-52Cs were painted with a white reflective underside, all the better to protect them from the heat and light that resulted when their nuclear payload detonated behind and below them. This paint scheme was also later applied to some B-52Bs.

BELOW A B-52C approaches a KC-135 Stratotanker. While this would normally indicate that refuelling was about to take place, the drogue device at the back of the KC-135's boom suggests that some sort of icing trial is in progress instead. The B-52 cannot refuel from a drogue device – better known as a 'basket'. (USAF)



RIGHT A B-52D being refuelled in flight in 1982. The aircraft still wears its camouflage from operations over Vietnam during the previous decade. (USAF)



B-52D

The B-52D closely resembled the B-52C, but lacked the recce pod capability and added external stores carriage on conventional munitions racks. As such it was really a dedicated long-range bomber. It featured a gloss black underside that was intended to make it less vulnerable to visual acquisition and tracking by searchlights.

The D-model was also subject to several modifications prompted by an increasing Russian missile threat. Modified for the new low-level penetration techniques that would mitigate an increasing SAM threat, the aircraft could now carry GAM-72A 'Quail' decoys (later referred to as ADM-20s). Quail was first carried on SIOP alert in 1962, and featured radar reflectors that would present a threat radar operator with a large target that would be almost impossible for him to distinguish from the B-52 itself. The Quail also had an internal payload capability of either chaff or radar repeater (to further confuse the radar picture), as well as an infrared 'burner' in its tail to draw IR threats away from the aircraft. While eight of these could be carried internally by the B-52, it was more usual to see only two carried operationally – enough to give the B-52 a slightly better chance of penetrating enemy airspace unscathed. The Quail was used by the B-52 until 1978, when its usefulness was judged to be limited in the face of increasingly more capable threat radar systems.

The B-52D also had a set of 'black boxes', paid for under a Quick Reaction Capability (QRC) programme, which combined to offer a cheap if not quite cohesive form of electronic countermeasures (ECM) system. Installed in three phases, it provided advance warning of search radar, and allowed the electronic warfare officer (EWO) to counter ground and airborne intercept threat radars and the missiles that they guided.

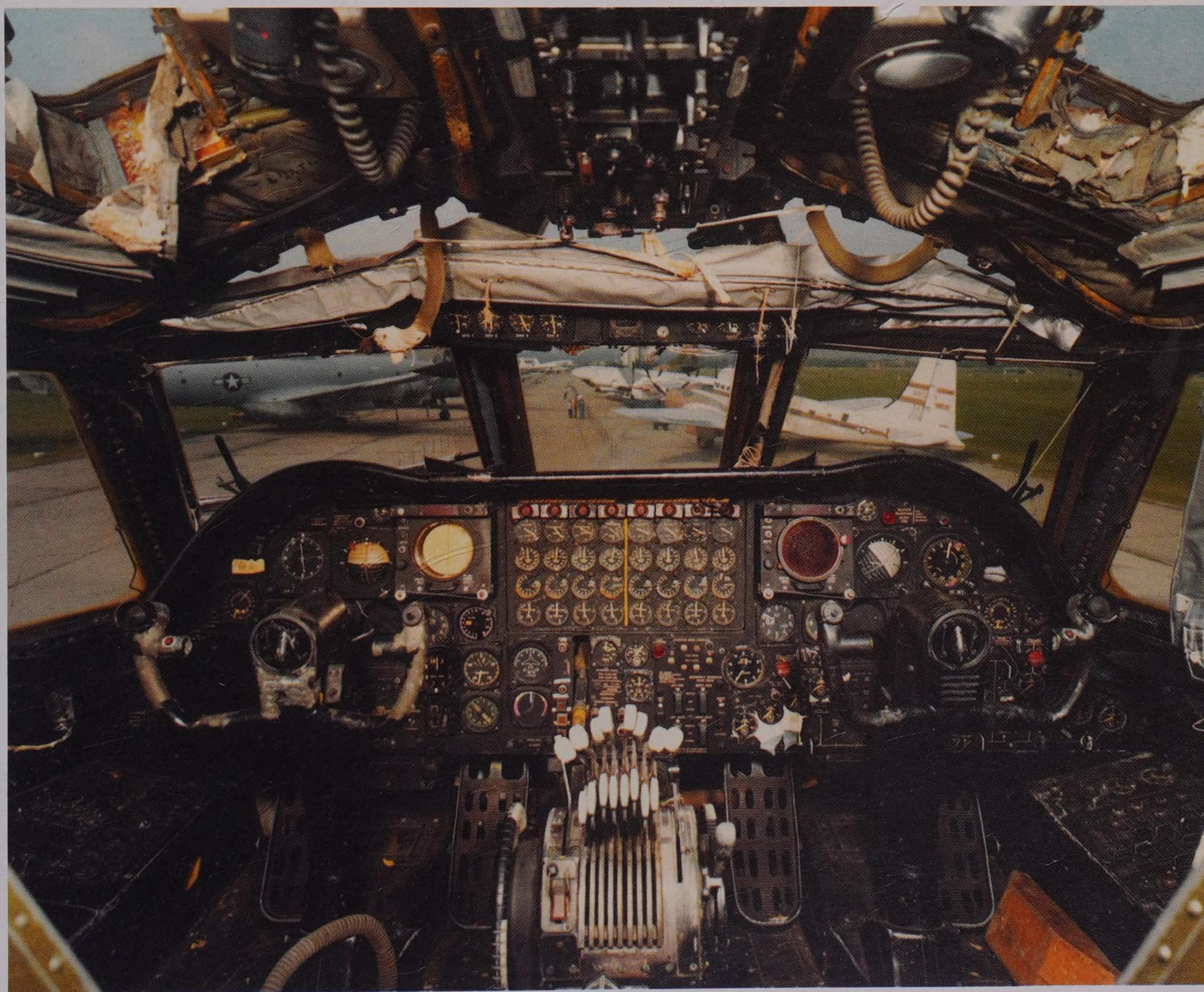
CENTRE AND LEFT A B-52D sits on the ramp with a GAM-72 Quail decoy in front of it. The Quail was first carried in 1962 and was meant to give the B-52 a better chance of getting through the Soviet Union's SAM belt. In the second shot, the Quail is launched from the aircraft's bomb bay. (USAF)

RIGHT Boeing B-52D (S/N 55-0049), the first Wichita-built B-52D, in flight. (USAF)

Yet it was inferior to the single and cohesive ECM system that SAC wanted (but could not afford), and which would later be retrofitted, having first appeared later on the B-52H.

In 1964 the MA-6A bombing and navigation system was also replaced by the AN/ASQ-48, a 'hi-density' (sic) bombing system, according to

BELOW The B-52D cockpit incorporated radar scopes for the AN/ASQ-48 bombing system for the pilot and co-pilot, seen in this image either side of the artificial horizons. Note the green glare shields above the main instrument panel. (USAF)



RIGHT The B52E was similar enough to the D model that it did not require extensive flight testing before entering service. Here B-52E serial number 56-0631, the first E model built, flies low over the coast. (USAF)



BELOW Boeing B-52E (S/N 56-0635) being refuelled by Boeing KC-135A (S/N 57-1467). The refuelling boom extends to about 12ft during optimal refuelling conditions. (USAF)

the B-52D flight manual. This made conventional bombing significantly more accurate from high altitude, and also helped cue the GAM-77/AGM-28 'Hound Dog' missile. The Hound Dog was cleared for carriage by the B-52D in 1960 and was a large, supersonic missile that could fly high- or low-altitude ingress routes to its target. It carried a W28 'Class D' thermonuclear warhead powered by an underslung P&W J52 turbojet, and was carried (two per B-52) on wing pylons inboard of the innermost engine nacelles. The missile was retired in 1978.

B-52E

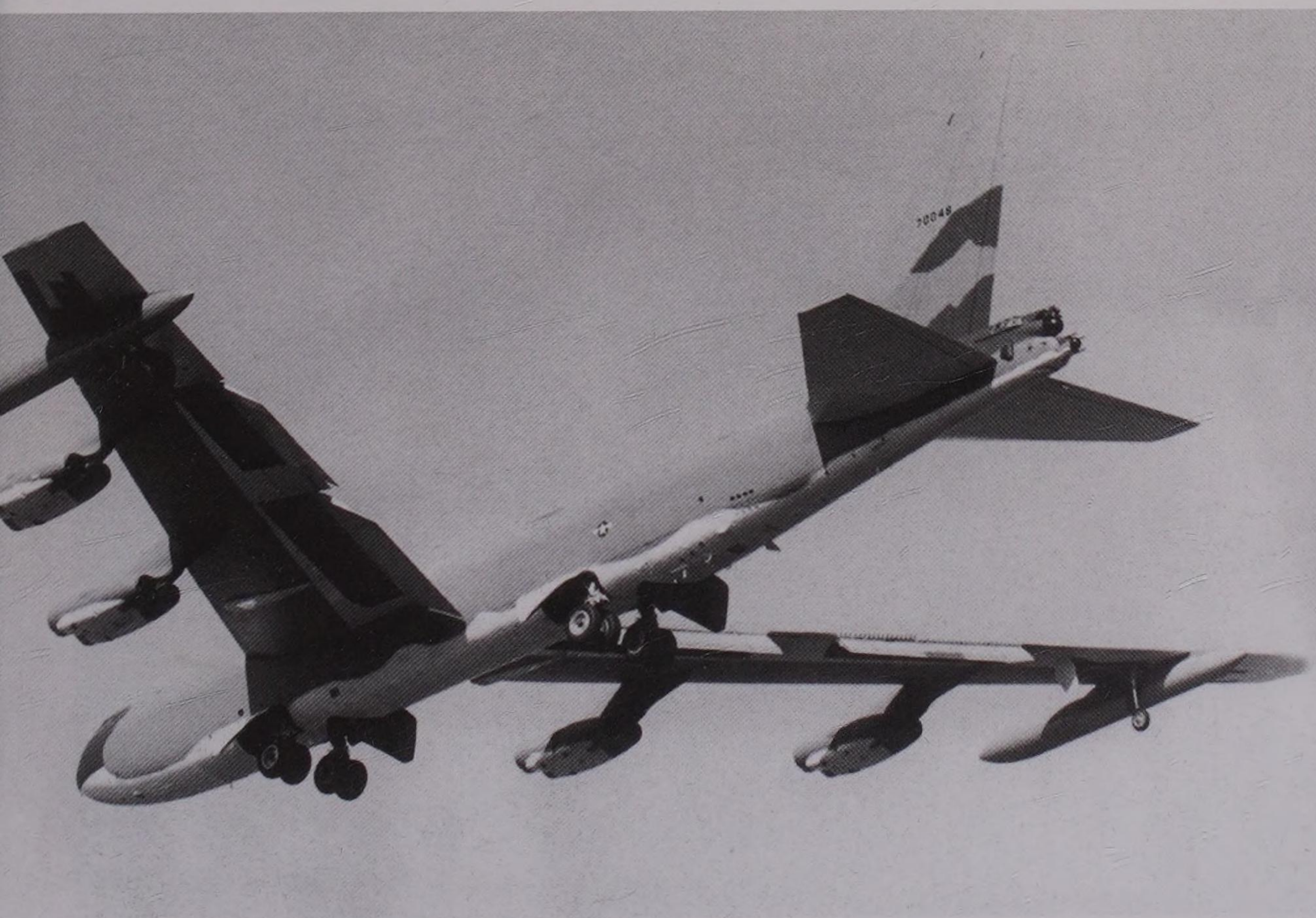
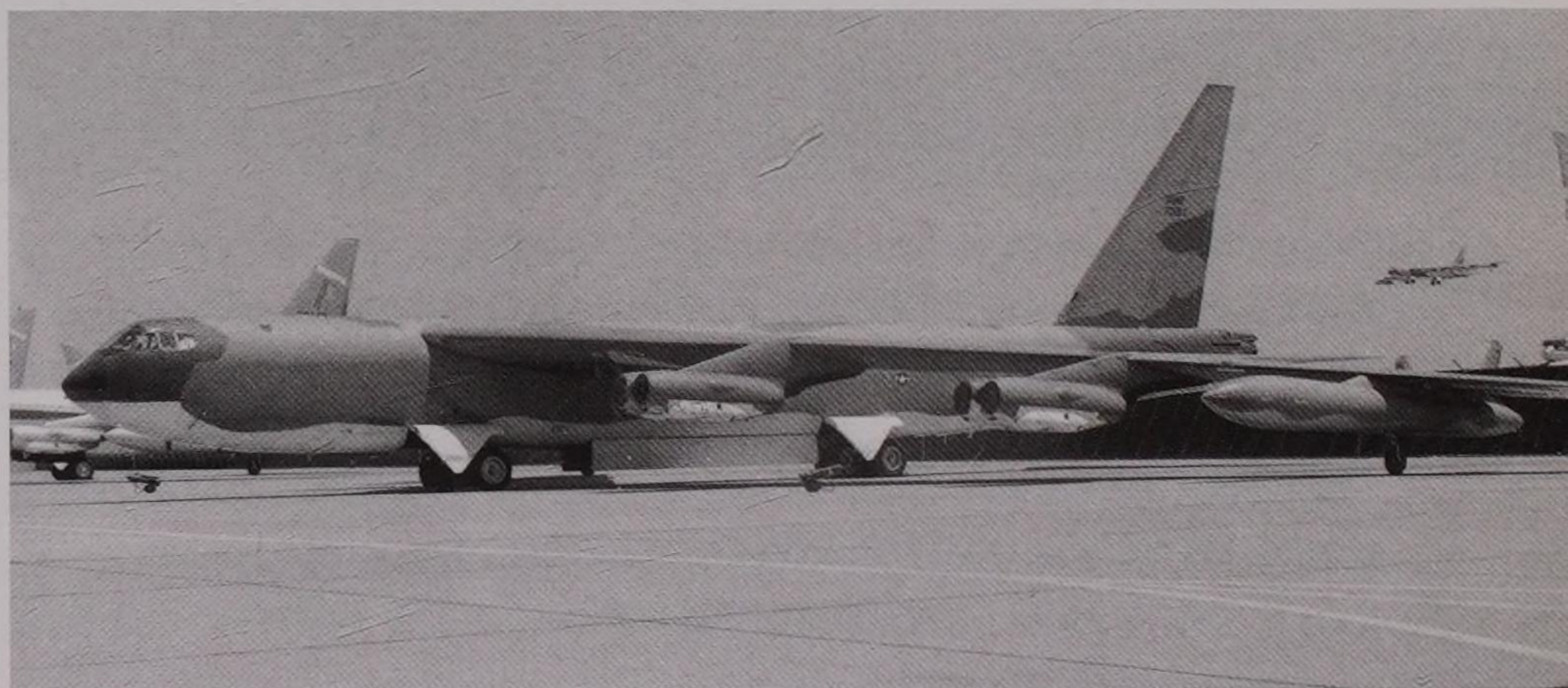
The B-52E was equipped with the AN/ASQ-38 bombing-navigation suite, an improvement over the B-52D's original ASQ-48, and one that featured the more capable AN/ASB-4 navigation and bombing radar. It was not a perfect system, but after continuing modifications until 1964 it was improved to the point where it could also equip future B-52 variants. This marque boasted other avionics improvements, but other than deletion of the external stores capability was otherwise similar to the B-52D.



RIGHT A B-52F rolls out of the Boeing factory with its vertical tail folded down to allow clearance. In the foreground, a detailed view of the B-52 tail turret is available: crew entry hatch (right), drag chute compartment door (middle) and the ammunition access door (left). (USAF)

B-52F

The B-52F was the final Stratofortress to be built prior to a major redesign. It featured -43W turbojet engines that produced 13,750lb of thrust, and was fitted with an improved water injection system. It also had engine-driven AC (alternating current) generators that would become standard on the two following B-52 variants.



ABOVE AND LEFT

A sequence of images showing the B-52F. Above left, water injection has been engaged and the aircraft hauls aloft a pair of AGM-28 Hound Dog missiles. Boeing B-52F (S/N 57-0153) of the 93d Bomb Wing at Castle AFB, California, is photographed above on 1 August 1969. Note the distinctive fairings on the left side of the engine nacelles. Finally, Boeing B-52F (S/N 57-0048) of the 736th Bomb Squadron, 454th Bomb Wing, Columbus AFB, Mississippi, is photographed left on approach to land in October 1966. (USAF)

RIGHT A B-52G loaded with suitably camouflaged Hound Dog missiles sits 'cocked' on nuclear alert as the crew disembark the crew van and rush to the entrance hatch. (USAF)



BELOW The B-52G was an important element in Global Shield 79, the largest and most comprehensive Strategic Air Command exercise in more than 20 years.

This example was photographed near Seymour Johnson AFB, North Carolina. (USAF)

B-52G

The B-52G was the first of the two redesigned variants of the Stratofortress, allowing the aircraft to fly different missions and be more capable at those to which it was already assigned.

Externally, it had a redesigned wing and an 8ft shorter vertical fin. This became known

as the 'short fin', while previous variants were henceforth referred to as 'tall tails'. Its internal fuel capacity was increased to 46,000 gallons through built-in 'wet wing' fuel tanks, providing an increased range of more than 2,000 miles. The B-52G gun turret was now completely automated, and the aerial gunner was relocated



forward to the main crew compartment, which had itself been redesigned. The navigators and EWO now found themselves facing aft, and the gunner remained facing aft but was at least now provided with an ejection seat on the lower deck.

The gunner's relocation was made possible by the introduction of the AN/ASG-15 FCS in place of the MD-9 DFCS. The ASG-15 featured separate radar dishes for search and track like its predecessor, but now linked the guns' line of sight with a television camera that meant the gunner no longer needed to occupy the tail turret. The ASG-15 had around 20 modes of operation, but in auto mode the two radars searched for and tracked targets while a computer aimed the guns; in manual mode the gunner used the closed circuit TV to aim the guns using hand controls.

The B-52G also introduced engine-driven hydraulic pumps, lateral control through the use of spoilers only, fixed external fuel tanks (700 gallons each), and an auxiliary fuel tank that fed the engines directly. While it could carry the Hound Dog, it also became the first B-52 to operationally carry the former's replacement, the AGM-69A SRAM (short-range attack missile).



ABOVE AND BELOW The B-52G showcasing two slightly different camouflage schemes, but fully loaded with AGM-86 air-launched cruise missiles in both images. Above, the anti-flash white underside of this 416th Bomb Wing jet was retained into the 1980s (this image is dated 1982), whereas the B-52 below shows the white underside has gone, dating it to around the late 1980s or later. (USAF)





LEFT The Air Force's three strategic bombers fly in formation with the B-52H leading. In the middle ground is the Rockwell B-1B 'Lancer' (better known as the 'Bone'), while a Northrop B-2A 'Spirit' presents a slender target in the foreground. (USAF)

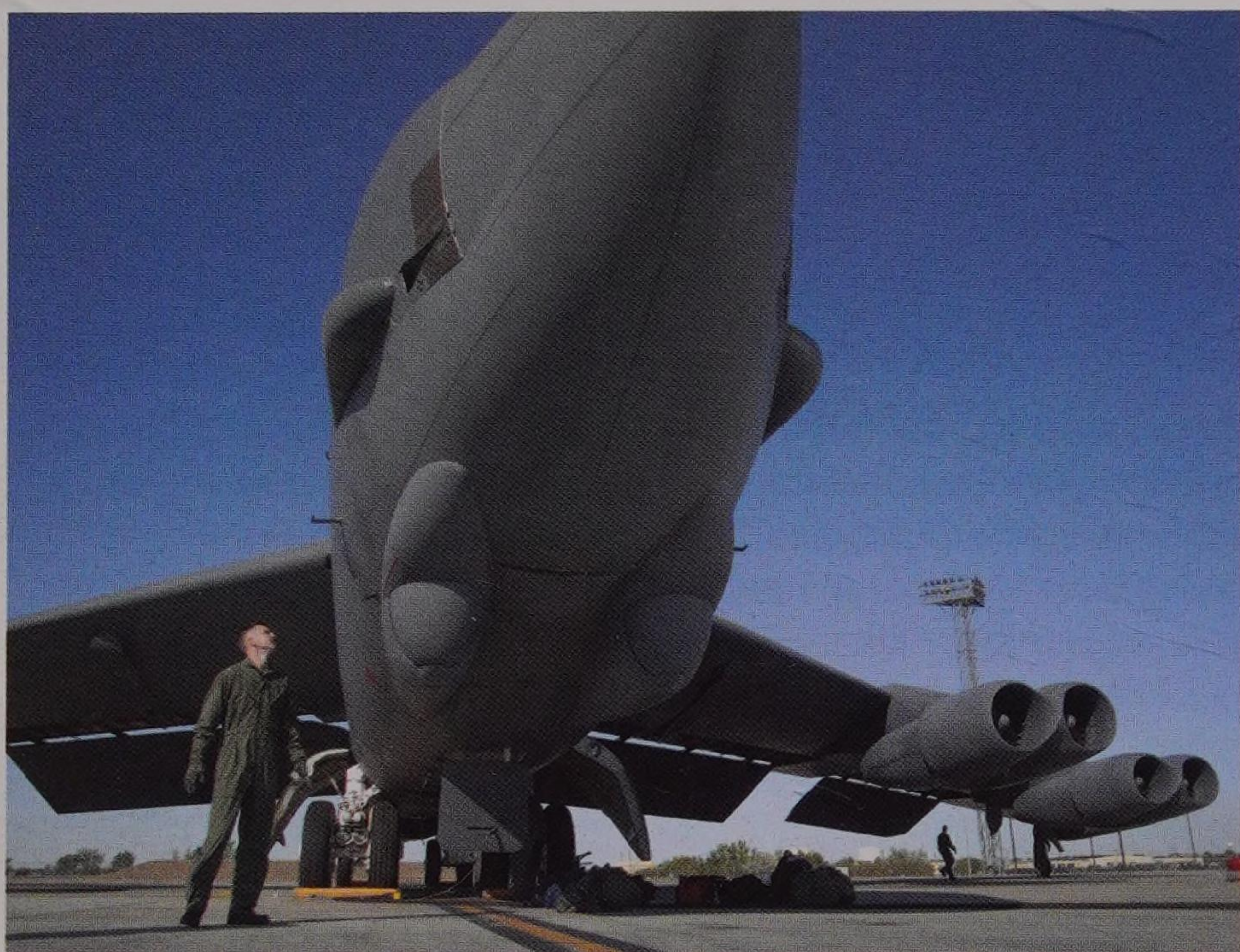
B-52H

The final version of the B-52, the H model was produced between 1960 and 1962. It saw the adoption of P&W TF-33-P-3 turbofans in place of the J-57s that had powered the series up until that point, and with each TF-33 producing 17,000lb of thrust, performance was greatly enhanced.

Improved avionics conferred a better offensive and defensive capability, as well as better low-level penetration, and the aircraft was intended to carry and deliver four Douglas AGM-87A Skybolt nuclear missiles. However, the Skybolt programme was cancelled and the B-52H carried the Hound Dog until the arrival of the SRAM. Throughout the 1970s Boeing had developed the AGM-86B air-launched cruise missile for the B-52H, and this turbofan-powered missile would give the Stratofortress a greater stand-off range than the SRAM, and would also eventually be built with conventional warheads (AGM-86C/D). Similarly, the introduction into service of the AGM-129 ACM in the early 1990s would also allow the B-52H to strike a target whilst standing off from dense and near-impenetrable threat rings.

The B-52H's DFCS was also upgraded. The four machine guns in the tail were replaced by a variant of the six-barrel, 20mm M61 Vulcan Gatling gun known as the T-171. Until the deletion of the gunner position and associated equipment in late 1991 the Vulcan was tied to an AN/ASG-21 DFCS that was much simplified over the ASG-15 of the B-52G, having only four modes of operation. By the mid-1980s the ASG-21's components had been upgraded to become almost completely digital.

The B-52H has been modernised through the installation of the AN/ASQ-151 electro-optical viewing system (EVS), which added new displays for the pilot and co-pilot to see the terrain ahead and drastically cut their workload at low level. Crucially, the displays meant that the B-52 cockpit windows could



ABOVE Captain Patrick Hook performs a walk-around inspection of a B-52 Stratofortress bomber at Minot AFB, North Dakota. The aircraft belongs to the 23d Bomb Squadron, 5th Bomb Wing. (USAF)

RIGHT While the nuclear strike mission means that security around the B-52 is always tight, this image is of note because it clearly shows the blanking plate applied to the B-52H fleet following deletion of the aerial gunner and associated tail gun assembly. (USAF)



RIGHT A B-52H Stratofortress on the flight line at Minot AFB one chilly January morning. In the depths of winter, Minot experiences low visibility, below-freezing temperatures and gusts of wind up to 50kt. (USAF)

be 'buttoned up' – covered by flash curtains mounted inside the cockpit – which meant that the crew had no outward visibility beyond what the EVS displayed on their screens. The Rivet Ace electronic countermeasures upgrade followed hot on the heels of the EVS installation, adding a 40in tail extension in the process to accommodate the new ECM equipment.

Then followed the installation of the AN/ASQ-176 offensive avionics suite (OAS) in place of the ageing ASQ-38 bombing-navigation suite first installed in the B-52E. This upgrade was most important because it replaced the ASQ-38 with components that were not only more capable, but were actually digital solid-state items that were 'hardened' to resist the effects of an electromagnetic pulse – the pulse generated by a nuclear blast.

In 1988 Phase VI+ saw a further refinement of the ECM suite courtesy of the AN/ALQ-172(V)2, a new radar jammer. The CEM followed in 1994, introducing the integrated conventional stores management system upgrade to the OAS. ICSMS was developed for weapons that required a MIL-STD-1760 data bus (JDAM, for example). Whilst it incorporated some hardware components, including a 1760-compatible ICSMS weapons adapter pylon, it was in effect a 'flight computer program' (FCP) consisting of a flight management system (FMS) and stores management overlay (SMO). The FMS controlled navigation, radar, controls and displays, while the SMO contained all weapon control delivery functions. The AMI programme followed in 1999, as previously mentioned. This upgrade is discussed in detail in chapter 3.



ABOVE This B-52H cockpit photograph is from a high-tech simulator used by today's BUFF pilots. The H model cockpit represents the 'cleanest' layout of all the B-52 series, but is nonetheless still characterised by its 1950s-era design. In fact, very little has changed from the original B-52A design. (USAF)



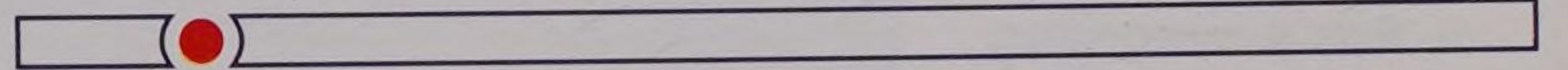
RIGHT The old and, well, the old! The Boeing B-17 was designed in the 1930s, only about 20 years prior to the B-52. Together, this B-17G and B-52H represent a bridge back to more than 70 years of aviation history. (USAF)





Chapter Two

The Stratofortress at war



While the B-52 was primarily employed as a long-range nuclear bomber between 1955 and 1991, it has never been called upon to execute this mission in anger. However, the Stratofortress has been extensively engaged in conventional warfare operations in a number of regional conflicts since 1965.

OPPOSITE With the fisheye lens adding some distortion to the view, a B-52H armed with six 2,000lb JDAMs refuels from a KC-135 over Afghanistan. The ability to carry lots of stores and loiter for extensive periods has made the B-52 an irreplaceable asset for battlespace commanders. (USAF)

RIGHT A B-52D Stratofortress from the 93d Bombardment Wing drops bombs over Vietnam. B-52Ds were modified in 1966 to carry 108,500lb bombs as part of the Big Belly modification programme. Prior to this the normal conventional payload was a meagre 51. (USAF)



BELOW Boeing B-52F (S/N 57-0139) sits at Andersen AFB, Guam, awaiting armament crews. In the foreground, the M-117 750lb bombs that will be loaded have been wheeled in. The B-52F was the first Stratofortress to see combat. (USAF)

In the intervening years, the Stratofortress has grown and developed to meet the new challenges faced by battlespace commanders, proving it to be a flexible and adaptable weapons platform in the process. Indeed, one needs look no further than the close air support (CAS) sorties flown over Afghanistan over the last decade to see exactly how the B-52H has been able to 'flex' to the needs of the war fighter.

The volume of combat operations and exploits that have involved the B-52 over

nearly half a century mean that this chapter can provide only a brief outline of these accomplishments. Emphasis has been given to operations in South-East Asia and the first Gulf War, since these involved the Stratofortress en masse.

Vietnam

On 18 June 1965, 30 B-52Fs took off from Andersen Air Force Base on the western Pacific island of Guam. They carried aloft a full load of conventional free-fall munitions, and their targets were Viet Cong positions located along the infamous 'Ho Chi Minh trail' that snaked from North Vietnam into the south of the divided country. In particular, the F models were to strike staging points in what was referred to as the 'Iron Triangle'. The mission signalled the start of an eight-year-long operation – 'Arc Light' – in support of the United States' effort to counter the spread of communism in South-East Asia.

Arc Light coincided with the US administration imposing a bombing halt over North Vietnam. The halt resulted in Operation Rolling Thunder, a gradual escalation of strikes starting in the South and in which interdiction



of the trail was an obvious priority. The trail was in effect a spider web of narrow tracks and paths that ran for approximately 1,900 miles, originating in North Vietnam and passing through neutral neighbouring Laos before entering South Vietnam. It was often used only at night and was largely concealed by a dense jungle canopy.

It is therefore no surprise that the B-52's expansive bomb load was ideally suited to 'carpet bombing' large areas of the trail. Arc Light was devastatingly effective at this – the Stratofortresses typically flew in two three-ship cells and released their bombs simultaneously; the combined effect of 80 tons of high explosive bombs would clear 1.5 square miles of jungle at a time.

Arc Light also created a major psychological challenge for the enemy – there were 400 Arc Light missions between April and June 1966 alone; and, because the majority of these missions were conducted against targets in South Vietnam where the air defence threat was low, the risk to the B-52 was almost non-existent. For America it was a win-win method of attack, and between 1965 and the end of 1967 the B-52 would fly 1,718 sorties against the trail.

Rolling Thunder saw the demand for Arc Light increase, resulting in B-52s being operated not only from Guam, but also from Kadena Air Base on the island of Okinawa, Japan, and from U-Tapao Air Base, Thailand. It had also seen the B-52F replaced by the B-52D and B-52G, and in 1966 the D model was subjected to 'Big Belly' (see page 160) modification. This dramatically increased its conventional payload to 108 bombs – almost twice as much as the B-52F could carry. With its gloss black undersides, this iconic variant of the Stratofortress would go on to fly the majority of the 126,615 B-52 sorties mounted during the course of the Vietnam War.

Linebacker I and II

In May 1972 the USAF and US Navy commenced Operation Linebacker, to interdict supplies and materials destined to support North Vietnam's planned invasion of South Vietnam. The target sets included bridges, railway yards, and petroleum, oil and lubrication plants, and the Linebacker I bombing campaign resulted in almost 29,000 sorties between April and June. The effect was tangible: only 30% of



LEFT Air refuelling gave the B-52D and B-52G the legs necessary to interdict the North Vietnamese supply line. Note the silver anti-flash curtains at the bottom of the front windscreens. (USAF)

BELOW Loading a Big Belly D model full of bombs took time, but the effort was worth it. The Arc Light mission made a significant dent in the morale of the North Vietnamese and the Viet Cong, whilst simultaneously rousing the spirits of the American GI. (USAF)



RIGHT Sharing the ramp with B-52Gs and Hs in the background, a lone B-52D sits freshly painted and ready for delivery back to its owner. On the first night of Linebacker II, 129 of these massive aircraft pounded North Vietnam. (USAF)



BELOW Six B-52Ds taxi to the active runway prior to taking off to strike Hanoi and Haiphong, North Vietnam, during Operation Linebacker II. The operation lasted only 11 days, but there were two nights that cost the B-52 dearly. (USAF)

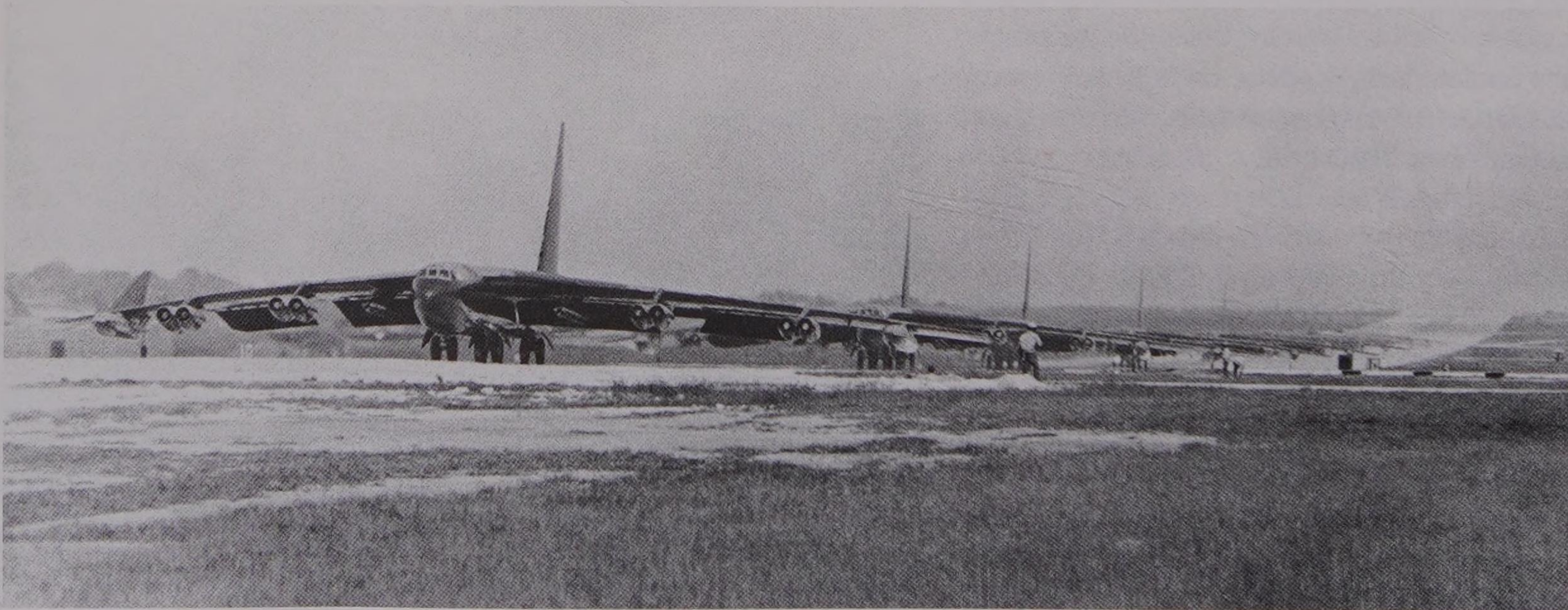
North Vietnam's supplies actually reached its front line units.

The Stratofortress had contributed well to Linebacker I, and on 8 October the North Vietnamese agreed to negotiate a peace settlement. But when the peace talks faltered once more in December 1972 President Richard Nixon ordered Operation Linebacker II to begin.

Linebacker II was a massive, 11-day effort that targeted not the predominantly logistical and tactical targets of Rolling Thunder and Linebacker I, but the strategic 'centres of gravity' that were the cities of Haiphong

and Hanoi. It was characterised too by the emphasis that was placed on exploiting the tremendous destructive firepower of the B-52 – the Stratofortress was placed at centre stage. Crucially, Hanoi and Haiphong were both located in Route Pack VI, the most heavily defended airspace the world had yet seen.

For 72 hours B-52Ds and Gs pounded the two cities and other key targets (such as airfields) that had, until now, been off-limits. On the first night, 129 Stratofortresses were launched, 87 from Guam, and all supported by various tactical fighters and electronic warfare aircraft. The B-52s struck airfields, railroads,



warehouses and power plants, losing two D models and a G model to the deadly SA-2 'Guideline' surface-to-air missile (SAM) in the process. F-4 Phantoms sowed chaff corridors – millions of strips of tin foil that created a zone 6 miles wide and 32 miles long – giving the B-52s a 32-minute 'window' in which the chaff clouds bloomed and hid the bombers from the SA-2s' search and acquisition radars.

On the second night the big bombers suffered not a single loss, although several were damaged by the now ubiquitous SA-2. But the third night was to be the bloodiest. Firing an estimated 300 SA-2s, the North Vietnamese had monitored the B-52 ground tracks and jamming techniques over the previous 48 hours, and were now better able to counter the 'Yankee air pirates'' electronic skulduggery. As a result, four B-52Gs and three B-52Ds were brought down. A fourth B-52D was damaged, eventually crashing in Laos as it attempted to limp to the safety of Thailand.

Following a brief stand-down over Christmas, the B-52s were once again bombing North Vietnam on 26 December. One hundred and twenty D and G models clawed their way into the air that evening. Protected by 113 tactical support aircraft, they overwhelmed the tired and now frayed North Vietnamese air defence network, suffering only a single loss.

A similar cycle of strikes, to include 200 bombing missions by B-52s against targets in the South, continued for three more days. Then, on 29 December, Operation Linebacker II was halted. At its cessation the B-52s' crews had

flown 729 sorties against 24 target complexes, delivering 15,000 tons of bombs. They had done so for a loss of 15 aircraft.

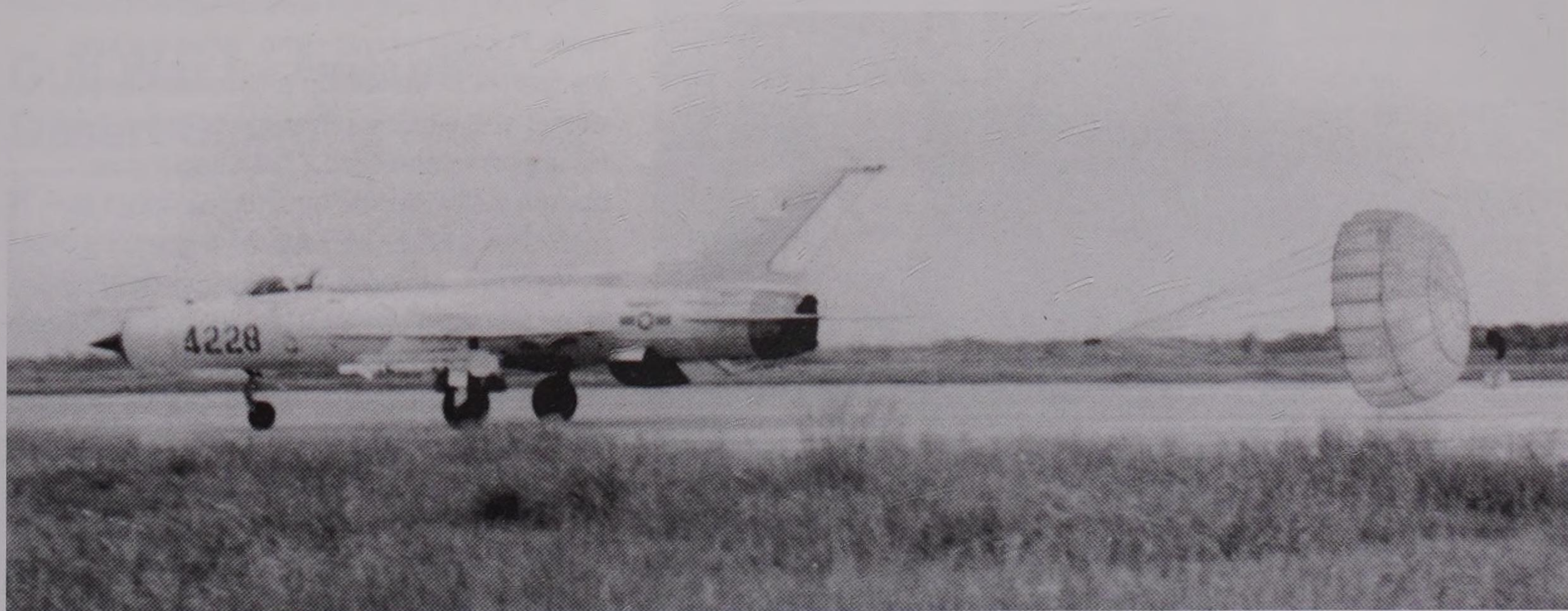
In mid-January 1973 Nixon announced the cessation of offensive operations in Vietnam, and on 28 January the last B-52 strike in South Vietnam took place. The Paris Peace Accords were signed soon thereafter, officially ending America's involvement in the war.

Kill MiGs

Linebacker II had seen cells of lumbering B-52s intercepted by MiG-21 'Fishbeds' of the North Vietnamese Air Force. Often the MiGs would be chased away by the bombers' F-4 escorts, and on other occasions they would simply fly co-altitude – but laterally displaced – from the Stratofortresses so as to report their altitude and headings back to the North Vietnamese ground controllers. However, some Fishbed pilots actively engaged the B-52s. Two of these occasions resulted in B-52 gunners being credited with confirmed kills that made the Stratofortress the largest bomber in history to down another aircraft. By the end of the campaign there were three additional unconfirmed kills.

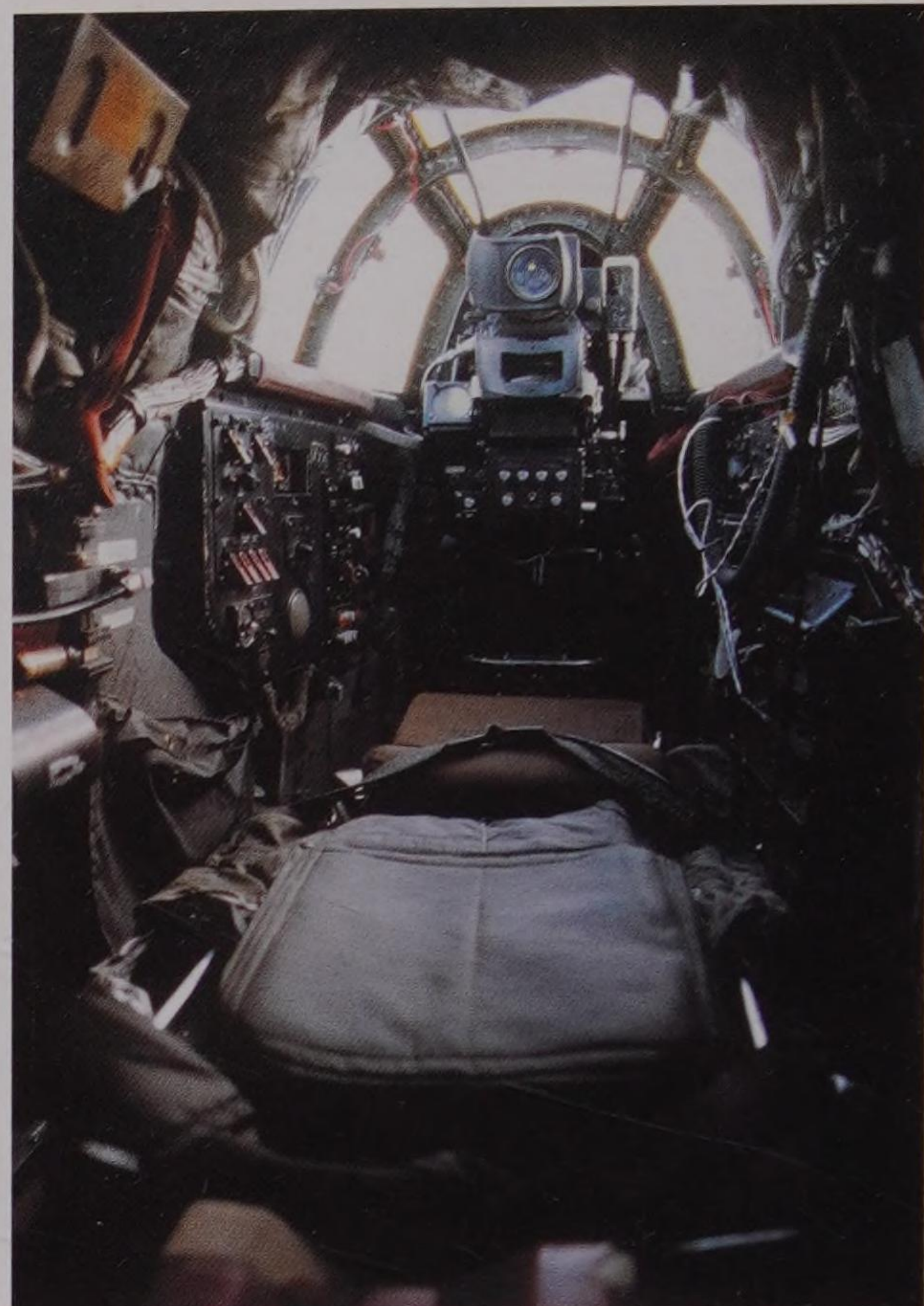
The first kill came on 18 December and resulted in the gunner of B-52D 55-06766, Staff Sergeant Samuel Turner, being awarded the Silver Star for his actions. The encounter is officially recounted by the Air Force's historical research centre as follows: 'S/Sgt. Samuel Turner, normally stationed at March AFB, California, but on temporary duty with the

BELOW The North Vietnamese Air Force operated MiG-21Fs and employed slashing attacks that were regularly successful. Noteworthy in this image is the presence of two AA-2 ATOL heat-seeking missiles. (USAF)





ABOVE AND RIGHT The B-52D aerial gunner's office, seen from outside and inside. Two gunners would score MiG kills during the war in South-East Asia, making the B-52 the largest bomber in history to down another aircraft. (USAF)



BELOW On 18 December 1972 near Hanoi, North Vietnam, Staff Sergeant Samuel Turner shot down a MiG-21. The 30-year-old was awarded the Silver Star for his combat actions. (USAF)

307th Strategic Wing based at U-Tapao airfield, Thailand, was the tail gunner aboard a B-52D, part of the heavy bomber force hitting targets in the Hanoi area'.

Turner describes the engagement: 'We were a few ships back from the lead aircraft. As we approached our target area, numerous surface-to-air missiles began coming up and exploding around us. We did not divert or turn back. We had our target and planned to hit it, regardless.

As we drew nearer to the target the intensity of the SAMs picked up. They were lighting up the sky. They seemed to be everywhere. We released our bombs over the target and had just proceeded outbound from the target when we learned that there were MIG aircraft airborne near a particular reference point.

'Our navigator told us the reference point was in our area and before long we learned the enemy fighter had us on its radar. As he closed on us I also picked him up on my radar when he was a few miles from our aircraft. A few seconds later, the fighter locked on to us. As the MIG closed in, I also locked on him. He came in low in a rapid climb. While tracking the first MIG, I picked up a second enemy aircraft at 8 o'clock at a range of about 7 miles. He appeared stabilized – not attacking us, obviously allowing the other fighter room to maneuver and conduct his run first.

'As the attacking MIG came into firing range, I fired a burst. There was a gigantic explosion to the rear of the aircraft. I looked out the window but was unable to see directly where the MIG would have been. I looked back at my radar scope. Except for the one airplane out at 8 o'clock, there was nothing. And within 15 seconds, even he broke away and we lost contact with him.'



B-52 UNITS, SOUTH-EAST ASIA

Andersen AFB, Guam

4133d Strategic Wing: February 1966–July 1970.

43d Strategic Wing (Provisional): July 1970–June 1972.

72d Strategic Wing (Provisional): June 1972–November 1973.

Kadena AB (Air Base), Okinawa, Japan

4252d Strategic Wing (Provisional): April 1967–April 1970.

376th Strategic Wing (Provisional): April 1970 onwards.

U-Tapao RTAFB (Royal Thai AFB), Thailand

4258th Strategic Wing (Provisional): April 1967–April 1970.

307th Strategic Wing (Provisional): April 1970 onwards.

The second kill came days later. Airman First Class Albert E. Moore, the gunner aboard B-52D *Diamond Lil*, downed a MiG-21 during a strike on the Thai Nguyen railroad yards on 24 December. According to the Air Force's after-action report, Moore 'acquired a fast-moving bogey on his radar scope. He notified his crew to dispense chaff and flares, got target lock-on at 4,000 yards, and as the bandit closed to 2,000 yards, opened fire. He continued firing until the blip blossomed on his scope, then disappeared.' His feat was witnessed by Technical Sergeant Clarence W. Chute, also a gunner, who saw the MiG-21 'on fire and falling away'.

Gulf War I – Operation Desert Storm*

In August 1990, Iraq's dictator, Saddam Hussein, ordered his elite Republican Guard to invade and occupy Kuwait. They met little resistance from Kuwait's military defences, and the occupation took the West by surprise. In response, the United States immediately

* It should be noted that the data available in multiple sources for B-52 operations during ODS can be conflicting. Distances flown, flight times, number of sorties and percentages of weapons employed as a total percentage of all Coalition bombs dropped all differ from one source to the next. Where possible official US Air Force figures have been used.

deployed military forces to Saudi Arabia under Operation Desert Shield. These forces were in the short-term to protect the Saudis from any further advance to the south by Hussein's ground forces, but would later engage in combat under Operation Desert Storm (ODS) to drive the Republican Guard out of Kuwait.

The B-52 would have a crucial role in ODS, practising a wide range of tactics that exploited both the latest technology available and relied on the traditional simplicity of carpet bombing. In doing so, the Stratofortress flitted between precision attacks against very specific strategic and tactical targets (such as key nodes of Iraq's command, control and communications network), and dropping mile-long sticks of free-fall bombs on dug-in Republican Guard units. In the case of the latter, the effect was predictably brutal and magnificently effective: Hussein's elite troops were bombed first into a state of psychological hysteria, and then into submission.

ODS started on the night of 17 January 1991, by which time a Coalition of military forces from around the world was in place. The Coalition's opening gambit that evening included one volley after another of cruise missile strikes, of which the AGM-86C conventional air-launched cruise missile (CALCM) played an important role. Seven B-52Gs from Barksdale AFB's

ABOVE Today, around 26 B-52Ds are on static display in museums around the United States and further afield. This example, *Diamond Lil*, is located at the US Air Force Academy, Colorado. It is the B-52D in which Airman First Class Albert E. Moore downed another MiG-21 on Christmas Eve 1972. *Diamond Lil* was flown from 1957 to 1983 and ended its career with over 15,000 flying hours. (USAF)



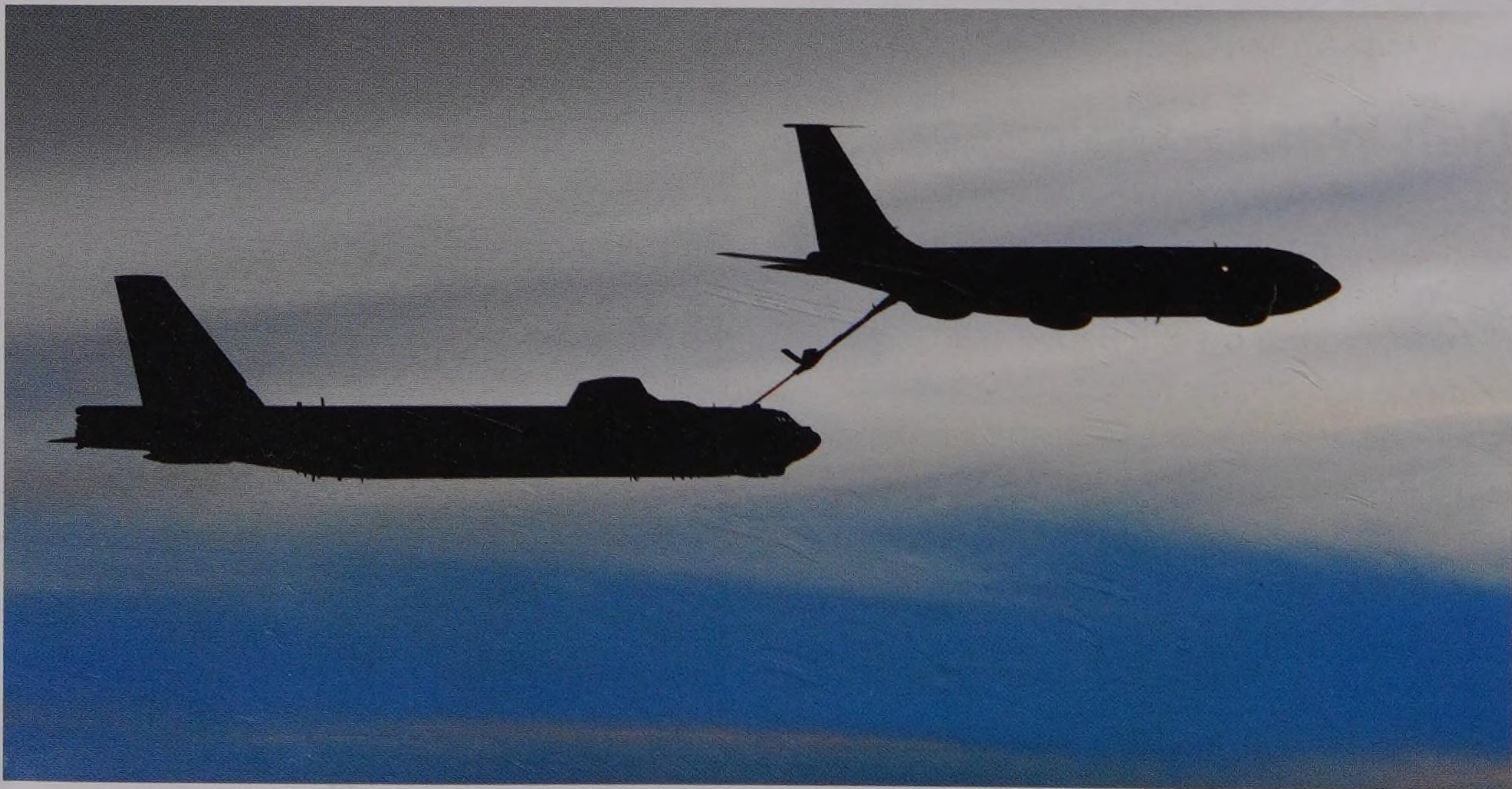


ABOVE AND RIGHT Seven B-52Gs from the 2d Bomb Wing launched 35 conventional air-launched cruise missiles (CALCMs) against Iraqi targets on the night of 17 January 1991. The CALCM has a small jet engine that powers it to the target, and can follow low-level routes to the target. (USAF)

RIGHT With spring-loaded wings and tail fins unfolded following release, an AGM-86 begins a gentle descent while its small engine turns over. The missile is of the 'launch and leave' variety, meaning that it operates autonomously once it has left the launch aircraft. (USAF)



RIGHT A B-52 Stratofortress from Minot refuels from a KC-135 Stratotanker. Given the tremendous distances involved, air refuelling was an essential element of the B-52's ability to strike targets in Iraq. (USAF)



2d Bomb Wing launched 35 of the conventionally-tipped missiles at high-priority targets in Iraq – leadership targets, command and control facilities and other high-value military targets – marking the missile's combat debut.

These missions, referred to as 'round-robins' because they covered 14,000 miles and 35.4 hours of non-stop flight, remained the longest aircraft combat sorties in history until 1996, when the B-52 would break its own record.

The extended duration of the B-52's missions from Barksdale meant that the first aircraft actually launched on 16 January. Officially at least the strikes were codenamed 'Senior Surprise', but the intense secrecy surrounding them led the crews to refer to them instead as 'Secret Squirrel'.

Crucially, the B-52's ocean crossings were supported by the Wing's own complement of KC-135 'Stratotanker' and KC-10 'Extender' tankers. Combined, these two types would provide more than 1,000 in-flight refuellings during the course of the war, representing around 8% of the total refuellings by all Coalition aircraft. The Wing's B-52s, meanwhile, would drop around a quarter of all the air-to-ground munitions expended by the Coalition.

While B-52s also operated within three provisional Wings stationed at airbases in Saudi Arabia, Barksdale was just one of three other airbases outside of the theatre of operations playing host to B-52Gs. In fact, more missions were flown by the 4,300th Provisional Bombardment Wing at Diego Garcia, a British island in the Indian Ocean, than any other bomber Wing in the war.

It was from Diego Garcia that the first B-52 strikes were flown. The Wing, comprised of B-52Gs and personnel from the 69th and 328th Bombardment Squadrons, targeted four Iraqi airbases and associated runways in addition to a number of improvised 'highway landing strips'. They flew low to avoid early detection by Iraq's integrated air defence system, employing cluster munitions to render them unusable.

The two other sites that played host to the B-52 were RAF Fairford, England, and Moron AB, Spain. Jim Sellars, one of the last aerial gunners, was one of 2,800 Air Force personnel who deployed from Louisiana to Moron alongside a contingent of 24 B-52Gs and three

KC-135s (the latter of which supplemented the 22 KC-135 and KC-10 aircraft already there). They were the largest bomber Wing of the conflict and were activated as the 801st Bombardment Wing (Provisional).

The deployment also represented a continued softening of the hard-line approach the Spanish government had once taken to allowing B-52s into its airspace. This position was clearly understandable, stemming as it did from the 17 January 1966 incident in which a nuclear-laden 'Chrome Dome' B-52 had experienced a mid-air collision with a KC-135, causing both aircraft to crash. Two of the BUFF's four hydrogen bombs ruptured, causing radioactive material to pollute farmland near Palomares; a third was lost at sea, while the fourth was recovered three months later some 12 miles off the Spanish coast.

In any case, Master Sergeant (retired) Jim Sellars' Wing launched its first combat mission from Moron 25 years to the day since the infamous Palomares incident: 17 January 1991. However, Turkey refused diplomatic permission for the bombers to transit its airspace. The BUFFs turned back. The intended target remained in operation.

Sellars and his crew would fly the Wing's second 'first' combat mission on 18 January. In contrast to the Barksdale's high-altitude attack profile using high-tech CALCMs, one cell (three aircraft) of Moron's jets would attack using 51 M-117R 750lb 'high drag' bombs, whilst another would drop 'slick' M-117s from high

BELOW An M-117, the 750lb free-fall bomb used during the 801st Bombardment Wing's (Provisional) first combat mission. The stock of M-117s, which is still being used at the time of writing, is said to date back to before the Vietnam War. (USAF)





LEFT M-117s were carried both internally and externally. Here, weapons loaders use an MJ-1 bomb loader to load the 750lb bombs on to the HSAB (heavy stores adapter beam) of a B-52G during Operation Desert Storm. (USAF)

altitude. These bombs were old – at the very least of Vietnam vintage – but sometimes the simplest plans are the best. CALCMs required a great many variables to go just as planned if they were to hit their targets; iron bombs were much more forgiving, even if they could not offer pinpoint accuracy.

Sellars recalls, ‘Our crew would fly in the number two position of the low-level cell, and our target was a Scud research and development facility in northern Iraq.

‘The six B-52 bombers did their slow “elephant walk” to the awaiting 11,800ft runway and one by one they departed. All six aircraft would perform a water injection take-off due to

BELOW Making a smoking take-off thanks to water injection, a B-52G thunders into the sky. The deceleration that was felt when the water injection was turned off was significant. During Desert Storm, B-52Gs delivered 40% of all the weapons dropped by Coalition forces. (USAF)



the heavy gross weights. Water take-offs were a deafening experience and when the water cut off after take-off it was like someone slamming on the brakes.

'The pilots checked in with the formation while we continued our climb to 28,000ft. Flying out past the Spanish coast over the Mediterranean Sea, we passed Gibraltar heading eastbound. Once we were over water the gunners chambered their four .50-caliber guns.

'We overflew Sigonella, Sicily, as we crossed the air refueling initial point where six KC-10 Extender tankers were orbiting and waiting for our arrival. This was a radio silent air refueling, so we just moved into position and plugged into the tanker to get our fuel. The pilots hung on the tanker for an hour as we took on nearly 200,000lb of fuel.

'Three hours later the pilot informed us we would be descending on our low-level route soon, so it was time to get ready for combat. I donned my flight helmet, fastened my parachute, checked my revolver, and pulled the safety pins on my ejection seat. I checked the fire control system, ensuring the guns were in the ready position, and as we crossed the On Watch Point I notified the pilot with a simple "Pilot, gunner's on watch, FCS is capable." I was ready to go.

'We started our gradual descent through southern Turkey and not long after the EW [electronic warfare officer] started picking up the first threat signals on his equipment. The pilot leveled off 500ft above the terrain as we flew a course through the haze-covered mountains on our way to the Iraqi border. A few minutes later, the navigator notified the crew that we were in Iraq. At first it seemed like any other low-level training flight, standard calls between the navigators and pilots, but it was not long before we picked up the first anti-aircraft-artillery (AAA) fire, and they harassed us for what seemed an eternity.

"Triple-A, triple-A at 12 o'clock!" The pilots were getting their first glimpse of the red glow of Iraqi tracer rounds coming up into the dark night sky. The AAA was not guided, the Iraqi gunners were filling the sky with a barrage of random gunfire, but they were well aware of our presence now.

'We continued along, avoiding the AAA and the jagged mountains, which was equally a

threat to our aircraft, on our way to the target area. I continued to monitor my indicator scope and kept the pilot apprised of the number three bomber's position. The AAA continued intermittently as we continued our course around the surface-to-air missile (SAM) threat rings along the way. We had a close call while flying down a deep valley where there was a lone gun sending tracer rounds upward in a fanning motion. All we could do was fly right over the gun, but as we got closer it stopped firing. The gunner either melted the barrels or evacuated his position thinking we were attacking him.

'As we left the mountainous region of northern Iraq heading southbound the pilots descended to 300ft above the terrain. They could see AAA off in the distance near the target area, but we pushed on. We soon crossed the initial point, which signaled the start of the bomb run. The AAA was now closer and in some instances the tracer rounds were going over the top of the aircraft, but so far none had hit us.

'The lead aircraft's bombs hit the target, turning the night to day. "OK, lead's on it, lead's got him," exclaimed the pilot. "All right! All right! All right!" shouted the co-pilot. There was no denying the excitement in the cockpit. Then, with a calm and collected voice, the navigator chimed in, "OK. We're happy. Sixty-five seconds to release," trying to re-focus the crew on our bomb run.

'The co-pilot reassured the crew that our track ahead of us was clear of AAA, but as soon as the words left his mouth the sky erupted with a barrage of gunfire to the southeast in and around the target area.

'At ten seconds we felt the slight rumble as the bomb bay doors came open. The navigator then started counting down to bombs release. "Five, four, three, two, one... Bombs away!" The wings of the aircraft trembled as the bombs fell to the ground below. As each bomb left its shackle, fins in the tail of each weapon opened, allowing them to rapidly decelerate away from the bomber. The radar navigator kept his eyes on the bomb indicator lights going out as the bombs fell to the target below. They all released except for one, which we would be bringing home with us.

'Soon after bombs away, the pilot banked the B-52 to the left, starting our post-target

turn toward our escape heading northward. The bomb bay doors closed and then the AAA harassed us once again. "Triple-A!" bellowed the pilot. A barrage of tracers came up at our nine o'clock position and this time it was close. The EW called for a maneuver and the pilot banked the bomber into a hard right descending turn.

"Altitude... altitude... ALTITUDE!" from the navigator's station, the voice gravely concerned as the bomber descended uncomfortably low to the ground. I stowed the control handles on my fire control system and leaned back in my seat; I wasn't sure what was going to happen next. Soon a reassuring "I got it" came over the interphone from the pilot and we started a slow climb.

'Once we were away from the target area the AAA let up quite a bit and we navigated a course back through the mountains to the Turkish border. The three low-level aircraft climbed to high altitude and rejoined with the three high-level B-52s. We completed an uneventful air refueling with the KC-10s and safely landed at Moron AB.'

Sellars' crew would go on to complete 11 more combat missions before the war came to a close and they returned to their home base in Louisiana. The three low-level crews were later awarded the Distinguished Flying Cross for the 801st Bombardment Wing's first mission.

For the remainder of the short war (combat operations ceased in March 1991), the B-52 performed exceptionally well, losing not a single aircraft and maintaining a mission capable rate of 81%. Whilst several aircraft were damaged by enemy surface-to-air missiles and AAA – infamously, one BUFF was even struck in the tail and empennage by an AGM-88 high speed anti-radiation missile fired by an F-4G Wild Weasel – none were downed. In total the B-52 delivered about 40% of all the free-fall munitions dropped by Coalition forces, flying 1,624 combat sorties and employing 72,000 weapons whose total weight exceeded 25,700 tons.

Ongoing desert operations

At the cessation of Operation Desert Storm, and with President Bush refusing to commit forces to the toppling of Saddam Hussein's dictatorship, British, American and French forces began flying a series of No-Fly Zone missions in northern Iraq. These sorties, which were part of Operation Provide Comfort, were intended to protect Iraqi Kurds from attack by Iraqi aircraft flying above the 36th parallel.

Over time the no-fly operation became Operation Northern Watch, and a similar operation – Southern Watch – was established to contain Iraqi aircraft south of the 32nd parallel (later extended to the 33rd parallel). For the B-52, deployments to ONW and OSW would continue for more than a decade – until the second Gulf War of March 2003, to be precise – and saw the aircraft deployed to Diego Garcia as part of the Air Expeditionary Group force structure.

ONW and OSW typically consisted of very

B-52 UNITS, OPERATION DESERT STORM

RAF Fairford, England

806th Provisional Bombardment Wing – January–March 1991.

This wing was activated specifically for ODS and comprised B-52Gs, aircrew and support personnel from the 62nd, 340th, 524th and 668th Bombardment Squadrons.

Diego Garcia AB, British Indian Ocean Territories

4300th Provisional Bombardment Wing – January–March 1991.

B-52G aircraft, aircraft and personnel drawn from the 69th and 328th Bombardment Squadrons.

Moron AB, Spain

801st Bombardment Wing (Provisional) – January–March 1991.

Prince Abdulla AB, Saudi Arabia

1701st Provisional Air Refuelling Wing – August 1990–March 1991.

This Wing was primarily composed of KC-10s and KC-135s, but from January 1991 onwards was assigned six B-52Gs from the 60th Bombardment Squadron.

1708th Provisional Bombardment Wing – August 1990–March 1991.

Initially composed of B-52Gs and personnel from the 69th and 524th Bombardment Squadrons, in December 1990 additional B-52Gs and personnel from the 69th, 328th, 524th, 596th and 668th Bombardment Squadrons were assigned to the Wing to bolster its numbers.

King Khalid Military City, Saudi Arabia

1703d Provisional Air Refuelling Wing – August 1990–March 1991.

This Wing was primarily composed of KC-135s, but by October 1991 was also assigned seven B-52Gs from the 69th Bombardment Squadron.



limited, and essentially punitive, 'response options' (ROs). ROs were combat plans that were built into the daily flying schedule (known as the Air Tasking Order, or ATO) that were only executed when the political leaders of the United States and the United Kingdom decided to punish Hussein for his misdemeanours (positioning anti-aircraft forces to threaten Coalition aircraft, for example).

When ROs were deemed an insufficient response to a graver matter – Iraqi forces amassing in a threatening manner, or a refusal to allow UN inspection of weapons in Iraq – more comprehensive and longer-running combat operations began. One of these, Operation Desert Strike of 3 September 1996, saw the B-52 once again employ CALCMs.

Desert Strike was in response to Iraqi forces advancing north and capturing Irbil, a town located in the Kurdish region north of the 36th parallel, and gave the B-52H the opportunity to make its combat debut. Also debuting was the pairing of the CALCM with the weapons bay-mounted common strategic rotary launcher (CSRL).

Two aircraft from Barksdale's 96th BS, 2d Bomb Wing, launched 13 AGM-86Cs, successfully knocking out power stations and communications nodes in southern Iraq. The mission, flown direct from Barksdale, just eclipsed the B-52's own 1991 world record for the longest bombing mission ever (Secret Squirrel). It was fitting that the Wing earned the

prestigious Mackay Trophy for meritorious flight as a result.

The H model and CALCM were once again deployed for Operation Desert Fox in 1998. Fox was a large-scale operation in which more than 75 Iraqi targets were struck from 16 December onwards, but the operation had initially been planned to commence on 14 November. On that day, B-52s were within 20 minutes of launching their AGM-86Cs (which would have been the opening salvo of the operation) when they were recalled in order to give the Iraqi dictator one last chance.

Trouble in the Balkans

Whilst Saddam Hussein continued to force the United Kingdom and America to spend huge sums of money enforcing NFZs in the north and south of Iraq, in the Balkans another conflict loomed.

For most of the 1990s NATO and the UN had been trying to control the activities of Slobodan Milošević, president of the Federal Republic of Yugoslavia (FRY), which had been formed from the republics of Serbia and Montenegro. Whilst the historical details of the region are complex, Albanian separatists – the Kosovo Liberation Army – from neighbouring Kosovo had in 1991 attacked government installations and police stations, beginning what Milošević viewed as an insurgency. In the intervening years the troubles escalated,

ABOVE With the end of Operation Desert Storm came more than a decade of No-Fly Zone enforcement. With time, the B-52H would get its chance to debut in combat. Here, an H model carries live CALCMs. (USAF)



BELOW A B-52H landing at RAF Fairford, England, following an Operation Allied Force sortie. What is particularly interesting about this image is the presence of two GBU-10 2,000lb laser-guided bombs on the port wing pylon. At this point in the operation, the B-52 was acting as a bomb truck, releasing munitions for other tactical platforms to guide on to targets. (USAF)



culminating in a programme of ethnic cleansing by FRY forces against ethnic Albanians.

While the United Nations would sanction the deployment of military peacekeepers to the region, NATO used military force to drive FRY forces from Kosovo. Operation Deny Flight became NATO's first-ever combat operation and came into being in 1993. However, it was principally about enforcing a NFZ over Serbia, and the B-52 was not used in anger at this time. However, as the situation worsened over the next few years a larger-scale offensive operation was increasingly becoming the only option for an otherwise-impotent NATO. And so it was that on 24 March 1999 offensive combat operations kicked off in earnest.



LEFT AND ABOVE On 24 March 1999 six AGM-86C-armed B-52Hs of the 96th BS, RAF Fairford, struck targets in the Federal Republic of Yugoslavia. In pre- and post-mission photographs, a CALCM is prepared for loading beneath the grey skies above RAF Fairford, and a crewman applies CALCM decals to the side of the aircraft following mission success. (USAF)

Spearheading the attack were six AGM-86C-armed B-52Hs of the 96th BS, which had deployed from Barksdale AFB to RAF Fairford as part of the 2d Air Expeditionary Group (2d AEG). The Group was also equipped by B-52Hs from the 69th BS and 23d BS, 5th BW, at Minot, North Dakota. In the days that followed (the conflict lasted only until 21 June), a work-around was required to solve a shortage of CALCMs. This was accomplished by launching smaller two- and three-ship cells of Stratofortresses that struck FRY targets and then recovered directly back at Barksdale. Their replacements would launch from Barksdale carrying CALCMs internally, land at Fairford, then begin mission planning.

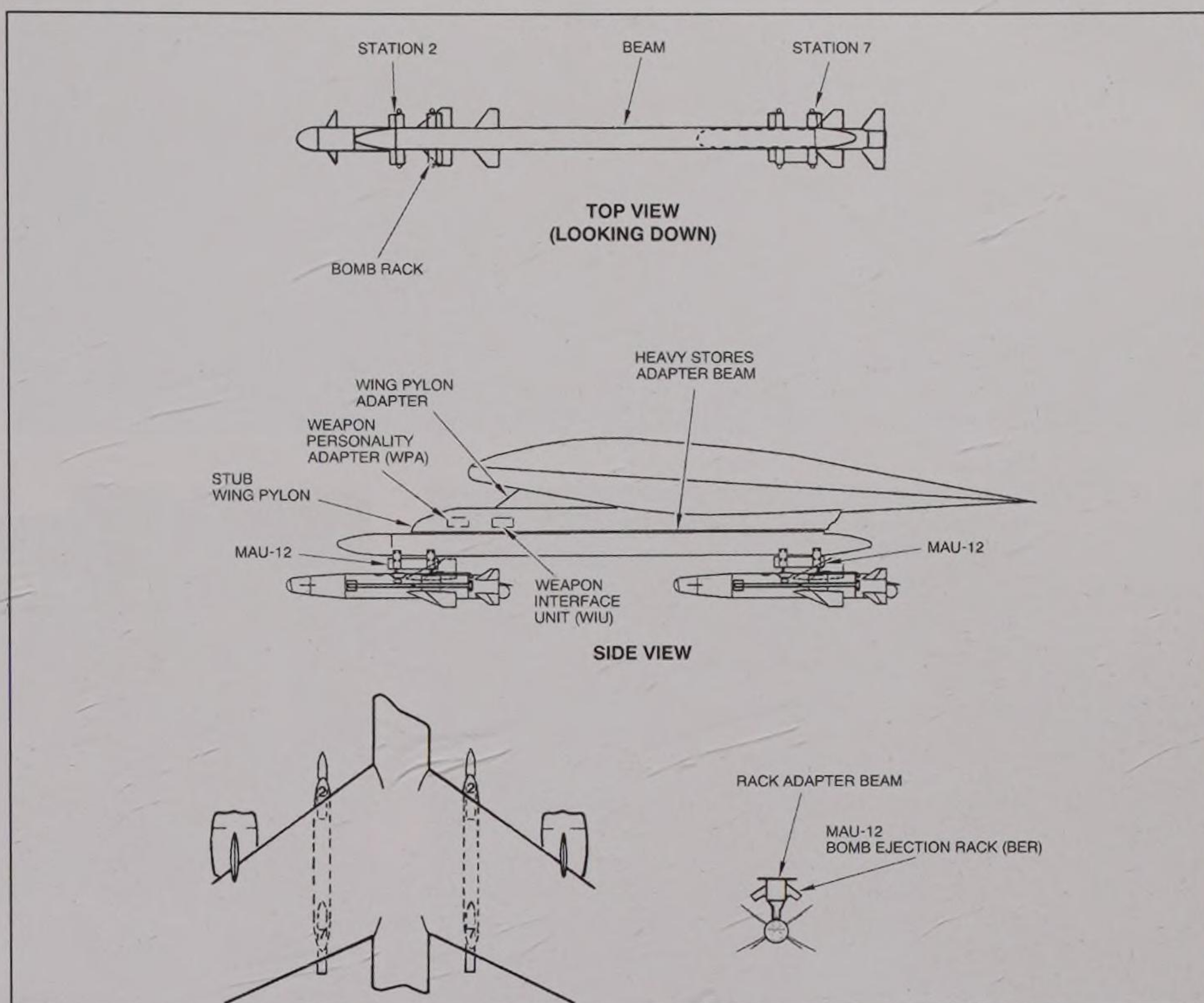
As the number of CALCM targets dwindled, and with NATO's targeting strategy moving more towards striking Serbian infantry and armour in Kosovo, the B-52 force switched to a conventional bombing role. Free-fall weapons were carried internally and on the wing pylons, and two BUFFs would typically fly formation with a B-1B 'Lancer' (better known as the 'Bone') in order to maximise the weapons effects of both types.

With the arrival of May, additional B-52Hs arrived at Fairford from Barksdale and Minot, bringing the total at the British base to 11. With them they brought laser-guided bombs (that could be 'buddy lased' by tactical fighters) and AGM-142 'HAVE NAP' TV-guided missiles.

Despite the extra precision firepower that the B-52s brought to the fight, their exceptionally heavy conventional bombing of FRY army staging areas in Kosovo is widely seen as the final push that was needed to bring about a peace agreement between Serbia and NATO on 9 June. With yet another opponent left in tatters, all 11 B-52s left Fairford for home on 23 June.

Operation Enduring Freedom

America's response to the terrorist acts of 11 September 2001 was decisive and unforgiving. Amidst the massive military force deployed for Operation Enduring Freedom, to topple the Taliban regime in Afghanistan and hunt the leaders of the al Qaeda terrorist movement, the B-52 would play a defining



ABOVE The AGM-142 missile debuted in combat during the 1999 Balkans conflict. As shown here, the B-52H can carry four of these missiles – two on each HSAB. (USAF)

LEFT A classic study of the B-52H in plan view. Careful analysis of the two wing pylons will reveal the presence of GBU-31 2,000lb JDAM munitions. With the arrival of two important upgrades and modifications, the B-52H became an autonomous hunter that could strike with pinpoint accuracy. This was a capability that would pay dividends in the so-called 'War on Terror'. (USAF)



LEFT Some of the first images out of Afghanistan after the fall of the Taliban showed contrailing B-52s high above Special Forces soldiers who called in airstrikes on enemy positions. The tranquillity of the B-52s' flights in the gin-clear skies was the polar opposite of the devastation that erupted when their 2,000lb bombs fell to earth. (USAF)



CLOCKWISE FROM ABOVE A range of free-fall weapons have been the staple munitions for the B-52H in Iraq and Afghanistan. The M-117 remains the cheapest weapon employed by the Stratofortress, offering good weapons effects against area targets and enemy vehicles and personnel. Meanwhile, the joint direct attack munition is ideal for employment against time-sensitive targets and those where absolute precision is required. Finally, 500lb Mk82 slick bombs offer similar capabilities to the M-117, the stocks of which have now been depleted.

(USAF)





ABOVE A B-52H from the 28th Air Expeditionary Wing takes off from Diego Garcia for a combat mission on 22 October 2001, in support of Operation Enduring Freedom. USAF B-2, B-1 and B-52 bombers would go on to expend more than 80% of the total tonnage of munitions dropped over Afghanistan, striking early-warning radars, ground forces, command-and-control facilities, al Qaeda infrastructure, airfields and aircraft. (USAF)

role. The 20th BS and 93d BS, 2d BW, at Barksdale deployed B-52Hs to Diego Garcia on 19 September, joining the 28th Air Expeditionary Wing. They flew their first strikes over Afghanistan on 7 October. Initially, they struck strategic targets – surface-to-air missile sites, early warning radars, Taliban leadership sites and communications nodes – but as the target list dwindled they were soon flying airborne alert missions to support Coalition troops on the ground.

By November the ten B-52Hs and eight B-1Bs at Diego Garcia had dropped 4,700 tons of munitions – about 72% of the total of 10,000 tons that had been expended by Coalition forces at that time. The



ABOVE The call for carpet bombing comes rarely in today's high-tech war on terror, but the employment of long 'sticks' of dumb bombs remains a useful and practical tactic in certain circumstances, including against concentrations of enemy fighters in Afghanistan. In this image, a Barksdale-based B-52H releases a stick of M-117s. (USAF)

Stratofortresses had been averaging five 12- to 15-hour sorties per day.

In January the following year the 93d BS was relieved temporarily by its sister squadron, 96th BS, but the 93d would return to Diego Garcia in May. As the nature of the conflict changed from striking fixed sites to attacking time-sensitive close air support targets, the investment in the Stratofortress' precision strike capability was fully utilised. The big bomber, flying day and night, loitered overhead for hours, dropping Joint Direct Attack Munitions on to fleeting targets that required absolute precision. They also engaged in psychological operations, dropping M129 leaflet dispensers containing messages intended to demoralise the enemy.

Eventually the Taliban regime toppled, but the prized al Qaeda targets fled into the mountains that border Pakistan and escaped largely unscathed. Today the Taliban continues to fight

RIGHT It was during Operation Iraqi Freedom that the AAQ-28 Litening II target pod saw its combat debut. Here, a 457th Air Expeditionary Group B-52H takes to the skies on that very mission. (USAF)



against the Coalition forces on the ground, meaning that air support remains a critical element of ongoing operations. As such, the Air Force's B-52s maintain a steady deployment rate in support of Enduring Freedom at the time of writing (August 2012).

Gulf War II – Operation Iraqi Freedom

On the night of 21 March 2003, Operation Iraqi Freedom (OIF) began. For more than a decade a belligerent Saddam Hussein had tested the patience of the West, but now the

governments of the United States and the United Kingdom decided that enough was enough.

OIF was planned to deliver a bombardment of such ferocity that the opening phase was commonly referred to as 'Shock and Awe'. Quite how shocking and awe-inspiring it actually was is a matter of opinion, but many of the precision strikes that illuminated the Baghdad skyline that night are attributable to the more than 100 AGM-86Cs released by B-52s of the 2d Bomb Wing.

The Wing's 93d BS split into two deployments – one to Diego Garcia, the other to RAF Fairford – which were tasked to strike command and control targets. In five months they would fly more

RIGHT Maintainers and firefighters wave at a B-52H Stratofortress bomber as it taxis for take-off on 7 October 2001, during Operation Enduring Freedom. The aircraft is about to embark on a strike mission against al Qaeda terrorist training camps and military installations of the Taliban regime in Afghanistan. It carries 12 GBU-31 JDAMs on its two HSAB pylons. (USAF)



RIGHT Desert tan flight suit with patches removed and a draped Stars and Bars flag over the instrument coaming indicate that this 2003 photograph was taken on either an Operation Iraqi Freedom or Enduring Freedom sortie. Today, the B-52 is in as much demand as ever. (USAF)

than 100 combat sorties and drop greater than 1,000,000lb of munitions. Amongst these was the AGM-86D, a version that replaced the blast fragmentation warhead of the AGM-86C with a penetrating warhead, and was now making its combat debut.

Meanwhile, the 5th BW deployed approximately 550 people and 14 B-52s, accruing 1,600 combat flying hours during 120 combat missions. The Wing dropped 3,000,000lb of munitions, including CALCMS, JDAMs, free-fall weapons, laser-guided bombs and leaflet dispensers. Importantly, the Wing also made history when it employed the AAQ-28 Litening II target pod to strike targets at an Iraqi airfield on 11 April 2003. The arrival of the pod completed the B-52's precision engagement capability, as it allowed the aircraft to lase its own laser-guided weapons on to precision targets. For the first time in its half-century history, the B-52 could now also autonomously search for, find, identify, target and engage moving targets on the ground.



The Asia-Pacific region

While not a combat operation, the B-52 does maintain a continuous bomber presence in the Asia-Pacific region in order to deter hostile acts against America's allies in the region, most notably by North Korea, but also by China. Andersen AFB on the island of Guam acts as home to this ongoing bomber rotation. While all B-52 squadrons support this mission, the 96th BS has assumed full-time responsibilities for it since early 2007 when it completed its final deployment in support of Operation Enduring Freedom in order to do so.



LEFT Closing up to the boom of a KC-135, the BUFF's aircraft commander gently teases the throttles to achieve the desired rate of closure. The tanker crews quite proudly tell all who will listen 'No kick-ass without tanker gas!', a phrase that is acronym-ised to NKAWTG. (USAF)





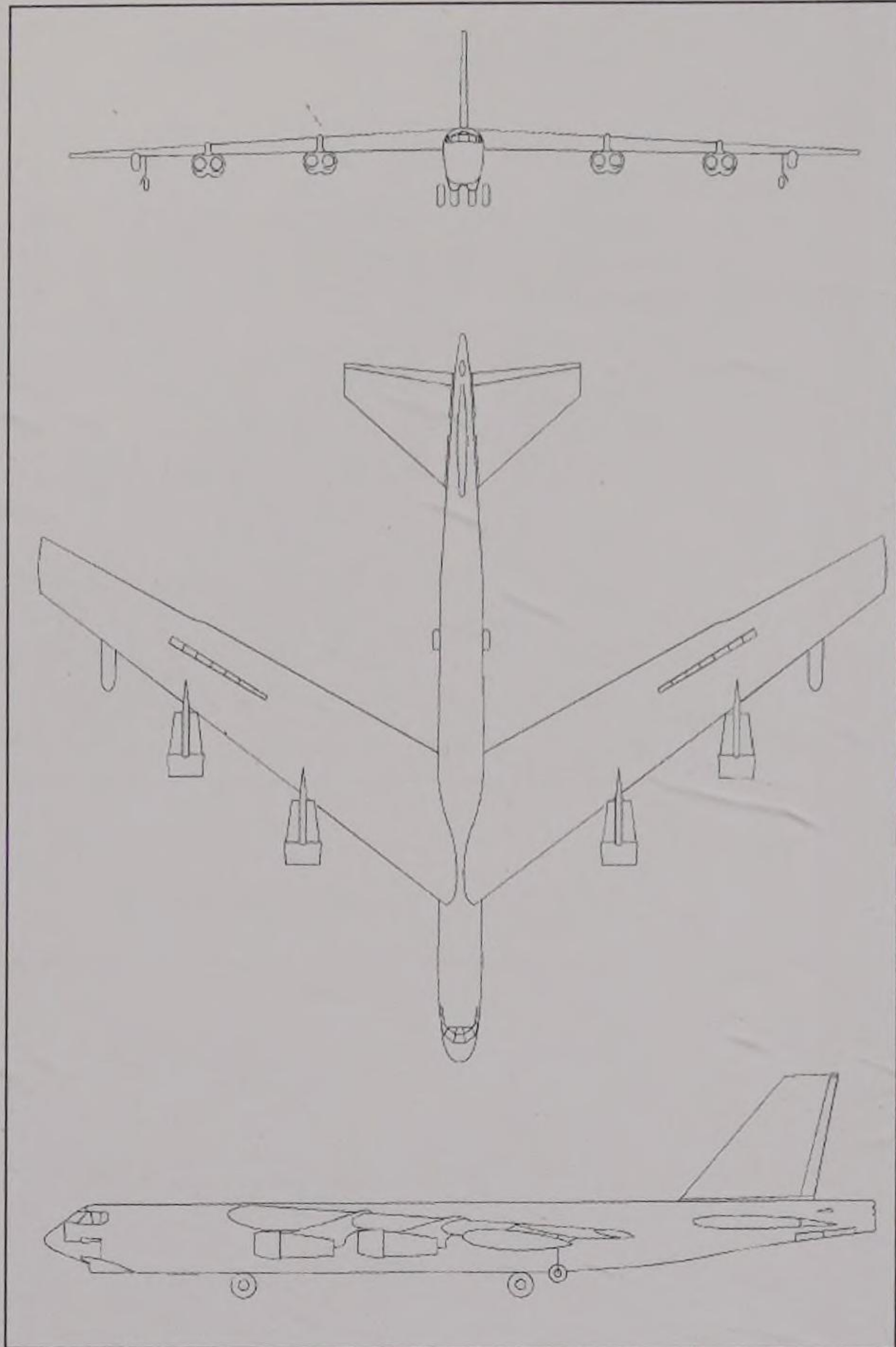
Chapter Three

Anatomy of the Stratofortress

General overview

The Boeing B-52H is a land-based heavy bombardment aircraft designed for long-range operations, flying at both high speed and high altitude. It is readily identifiable by its swept wings, four underslung nacelles housing a total of eight turbofan engines, a quadricycle main landing gear and a tip gear near each outboard engine nacelle. The aircraft's dimensions are impressive: 159ft 4in long, 40ft 8in high to the top of its fin (vertical stabiliser), a centreline outboard tread of 11ft 4in for the main tyres, and a width of 148ft 5in from tip gear to tip gear.

OPPOSITE The common stores rotary launcher is located in the bomb bay and is hydraulically powered. Between sorties, two weapons loaders attach inert SRAM missiles to the launcher. (USAF)



The Stratofortress is officially in the 400,000lb gross weight category, and has a 488,000lb maximum take-off weight. However, when undertaking nuclear strike missions it operates

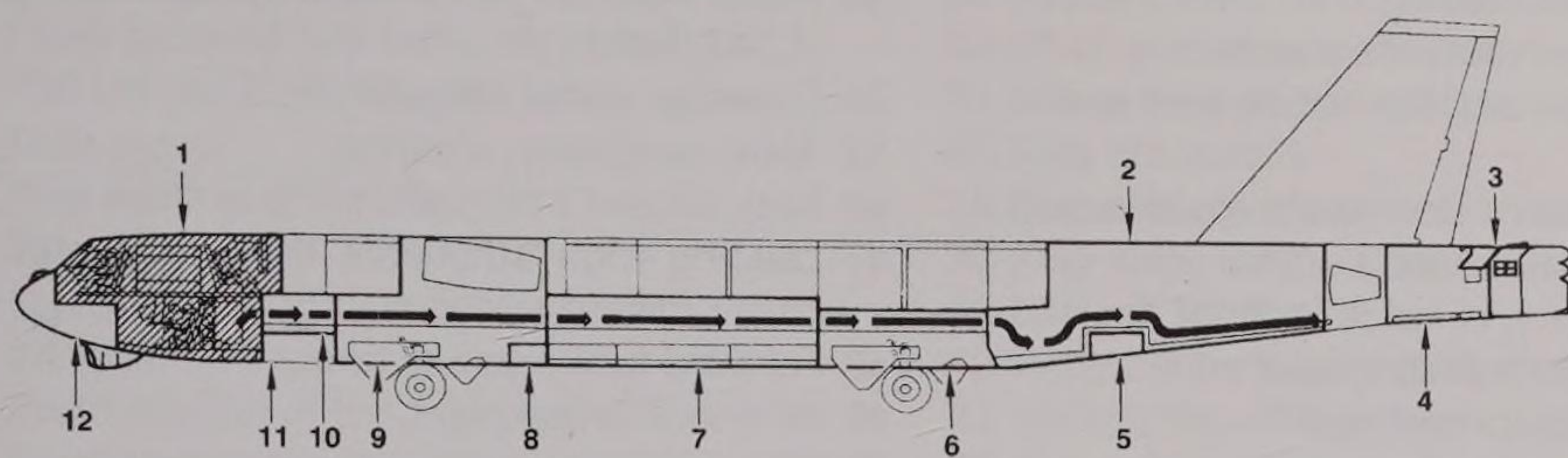
under a 'heavy gross weight extension' waiver that permits in-flight operations as high as 580,000lb. This allows the aircraft to take off at 488,000lb and to be subsequently air-refuelled to a weight of 580,000lb.

The aircraft has seating for ten crew members, although a basic crew of five is typically required to operate it. The crew compartment is divided into upper and lower decks, where all five – pilot, co-pilot, radar navigator, navigator and electronic warfare officer (EWO) – are provided with ejection seats.

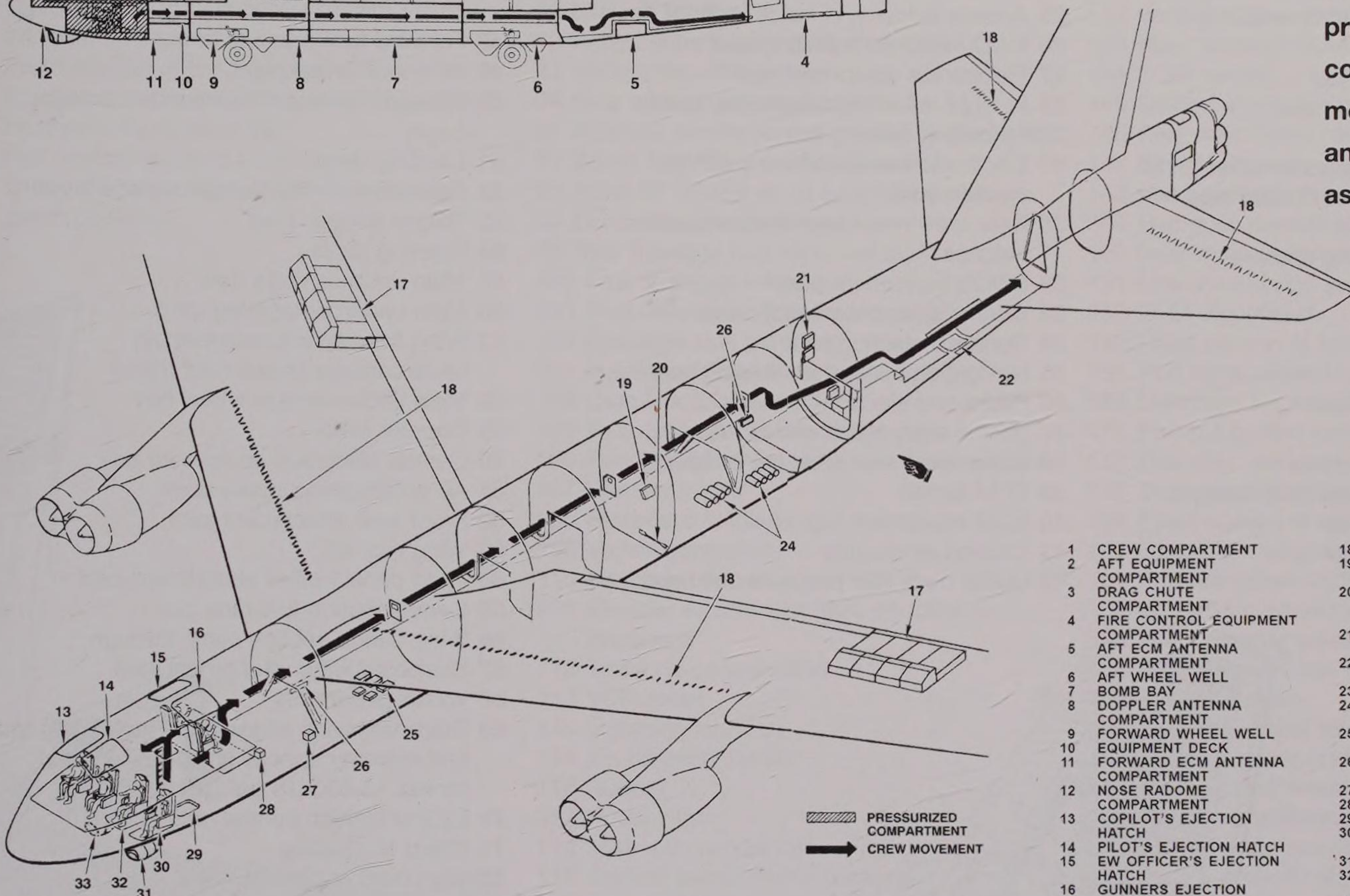
The pilots' stations are located at the forward end of the upper deck, while the EWO is seated in an aft-facing seat at the aft end of the upper deck. Prior to the Air Force's 1991 decision to no longer carry aerial gunners, the gunner would be seated to the right of the EWO. The radar navigator's and navigator's stations are on the left and right of the lower deck respectively. The navigators' seats are positioned forward of the main entry door. The crew compartment extends from a pressure bulkhead forward of the pilots' stations to a pressure bulkhead aft of the EWO's station, and movement of the crew between the upper and lower deck is facilitated by a ladder forward of the main entry door. A



RIGHT At 159ft long and 148ft wide, the B-52 is about the same size as a Boeing 767 airliner. However, its thinner fuselage and towering vertical tail create the illusion that it is actually much bigger. (USAF)

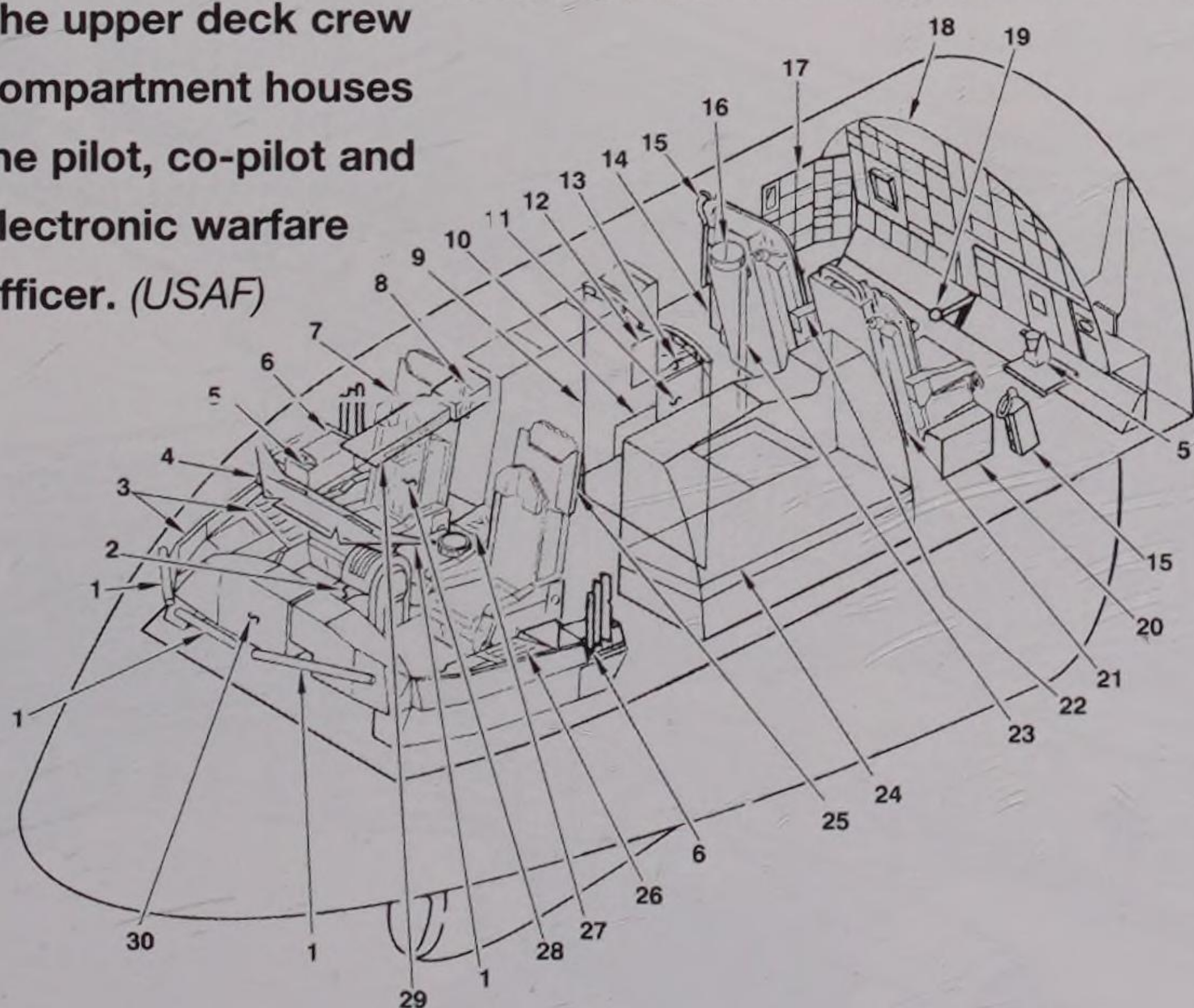


The general arrangement of the B-52, showing the pressurised crew compartment, crew movement areas and significant assemblies. (USAF)



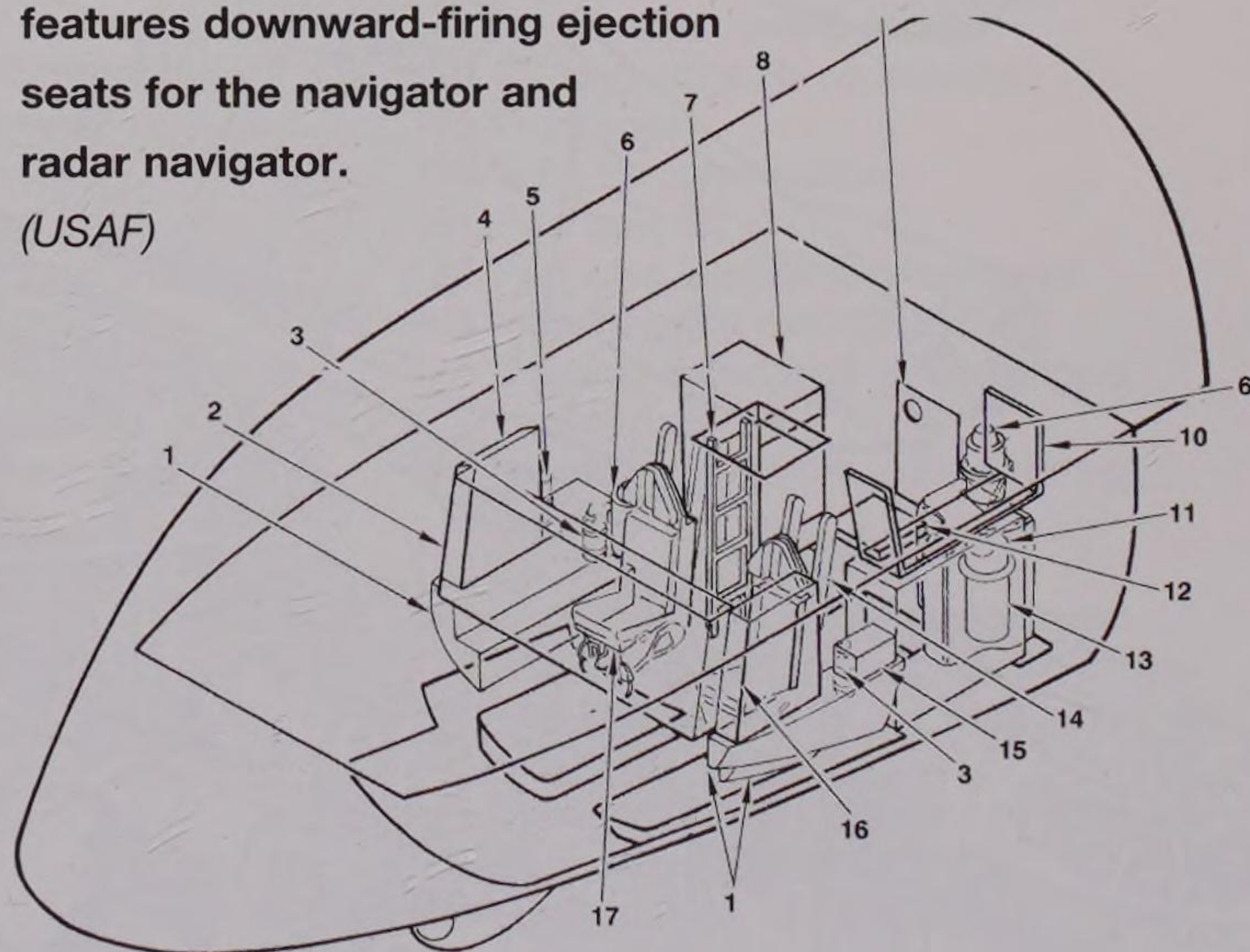
- | | |
|--------------------------------------|--|
| 1 CREW COMPARTMENT | 18 VORTEX GENERATORS |
| 2 AFT EQUIPMENT COMPARTMENT | 19 MISSILE SAFEING PINS AND STREAMERS STOWAGE |
| 3 DRAG CHUTE COMPARTMENT | 20 MISSILE GROUND SAFETY PIN INSTALLATION AND REMOVAL TOOL STOWAGE |
| 4 FIRE CONTROL EQUIPMENT COMPARTMENT | 21 AFT TRANSFORMER-RECTIFIER UNITS (3) |
| 5 AFT ECM ANTENNA COMPARTMENT | 22 AFT EQUIPMENT COMPARTMENT HATCH |
| 6 AFT WHEEL WELL BOMB BAY | 23 DELETED |
| 7 DOPPLER ANTENNA COMPARTMENT | 24 STARTER CARTRIDGE STOWAGE |
| 8 FORWARD WHEEL WELL EQUIPMENT DECK | 25 FORWARD TRANSFORMER-RECTIFIER UNITS (5) |
| 9 FORWARD ECM ANTENNA COMPARTMENT | 26 EXTERNAL POWER RECEPTACLE (3) |
| 10 NOSE RADOME COMPARTMENT | 27 AFT BATTERY |
| 11 COPILOT'S EJECTION HATCH | 28 FORWARD BATTERY |
| 12 PILOT'S EJECTION HATCH | 29 MAIN ENTRY DOOR |
| 13 EW OFFICER'S EJECTION HATCH | 30 RADAR NAVIGATOR'S EJECTION HATCH |
| 14 GUNNERS EJECTION HATCH | 31 EVS STV TURRET |
| 15 CHAFF DISPENSERS | 32 NAVIGATOR'S EJECTION HATCH |
| | 33 FLIR TURRET |

The upper deck crew compartment houses the pilot, co-pilot and electronic warfare officer. (USAF)



- | | |
|------------------------------------|--|
| 1 THERMAL CURTAIN | 17 EW OFFICER'S SIDE PANEL |
| 2 AISLE STAND | 18 DEFENSE STATION INSTRUMENT PANEL |
| 3 COPILOT'S SIDE PANEL | 19 MAIN REFUEL VALVE EMERGENCY CONTROL LEVER |
| 4 EYEBROW INSTRUMENT PANEL | 20 GUNNER'S FOOD STOWAGE BOX |
| 5 HOT CUP | 21 GUNNER'S EJECTION SEAT |
| 6 FOOD AND DATA BOX | 22 EW OFFICER'S EJECTION SEAT |
| 7 COPILOT'S EJECTION SEAT | 23 STANCHION |
| 8 SIGNAL LIGHT | 24 CREW BUNK |
| 9 NIGHT FLYING CURTAIN | 25 PILOT'S EJECTION SEAT |
| 10 FOOD STORAGE CHEST | 26 PILOT'S SIDE PANEL |
| 11 TOILET | 27 INSTRUCTOR PILOT'S SEAT |
| 12 FOOD WARMING OVEN | 28 PERISCOPIC SEXTANT CARRYING CASE |
| 13 DEFENSE INSTRUCTOR'S SEAT | 29 PILOTS' OVERHEAD PANEL |
| 14 EW OFFICER'S FOOD STOWAGE BOXES | 30 PILOTS' INSTRUMENT PANEL |
| 15 OXYGEN BOTTLE | |
| 16 PERISCOPIC SEXTANT MOUNT | |

The lower deck crew compartment features downward-firing ejection seats for the navigator and radar navigator. (USAF)



- | | |
|---------------------------------|--|
| 1 MISCELLANEOUS EQUIPMENT SHELF | 11 CENTRAL URINAL |
| 2 NAVIGATOR'S INSTRUMENT PANEL | 12 INSTRUCTOR NAVIGATOR'S TAKEOFF A LANDING SEAT |
| 3 OXYGEN BOTTLE | 13 POWER SUPPLY RACK |
| 4 NAVIGATORS SIDE PANEL | 14 RADAR NAVIGATOR'S EJECTION SEAT |
| 5 HOT CUP | 15 FOOD STOWAGE BOX |
| 6 DRINKING WATER CONTAINER | 16 RADAR NAVIGATOR'S SIDE PANEL |
| 7 LADDER | 17 NAVIGATOR'S EJECTION SEAT |
| 8 RIGHT EQUIPMENT RACK | |
| 9 PRESSURE BULKHEAD DOOR | |
| 10 LEFT EQUIPMENT RACK | |

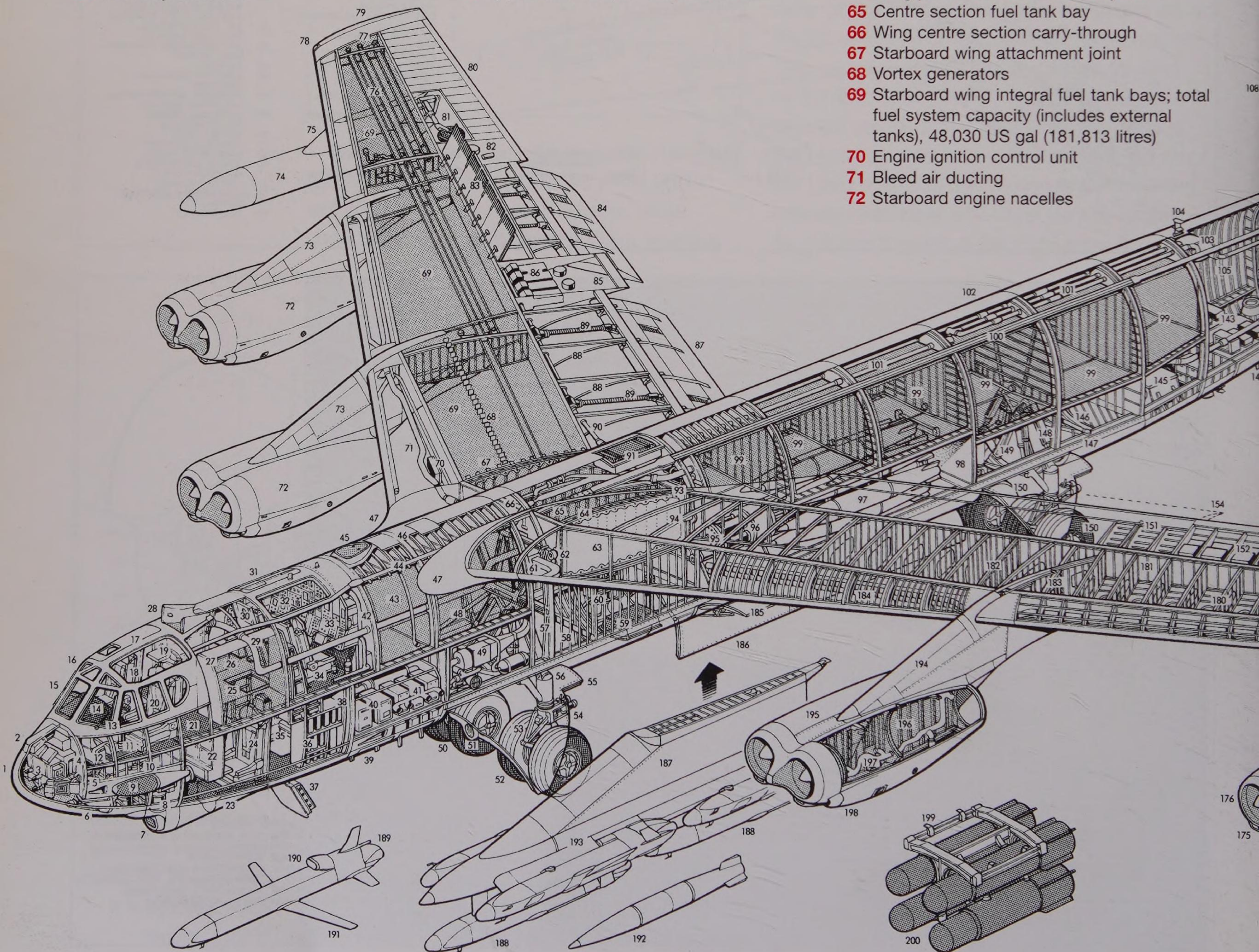
Cutaway view of Boeing B-52G

Stratofortress (Mike Badrocke)

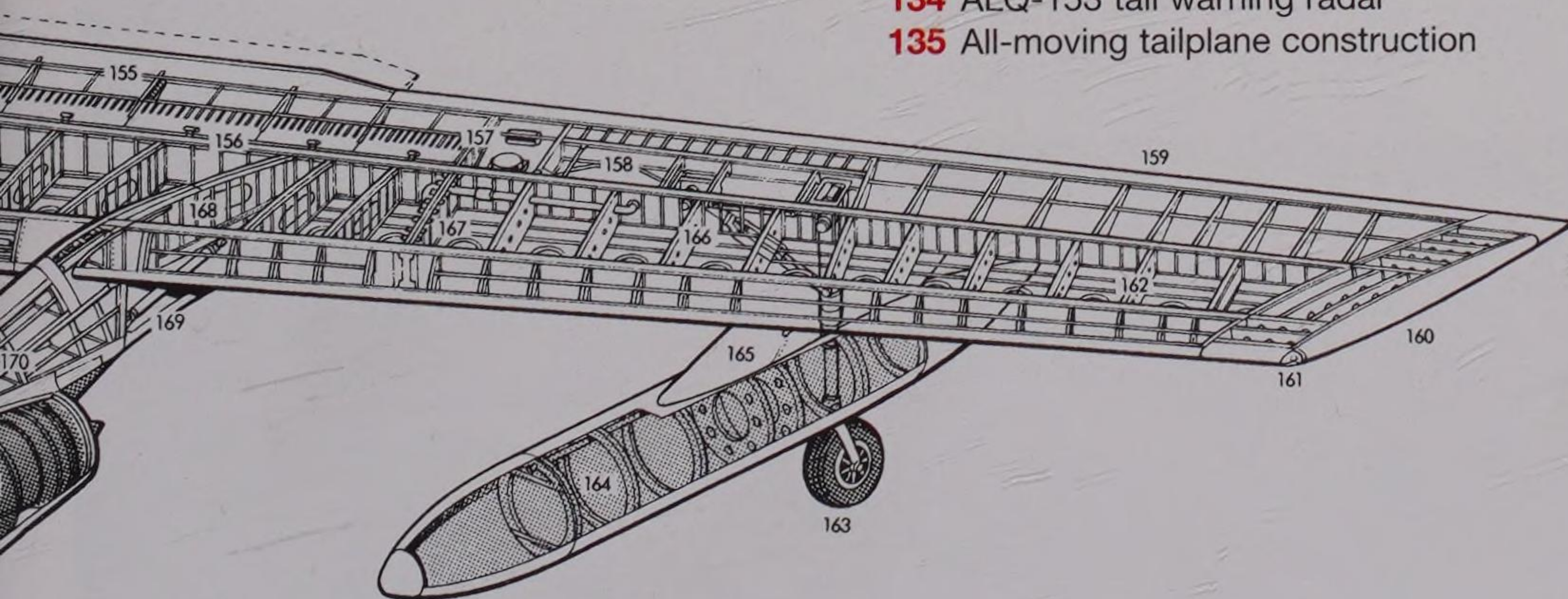
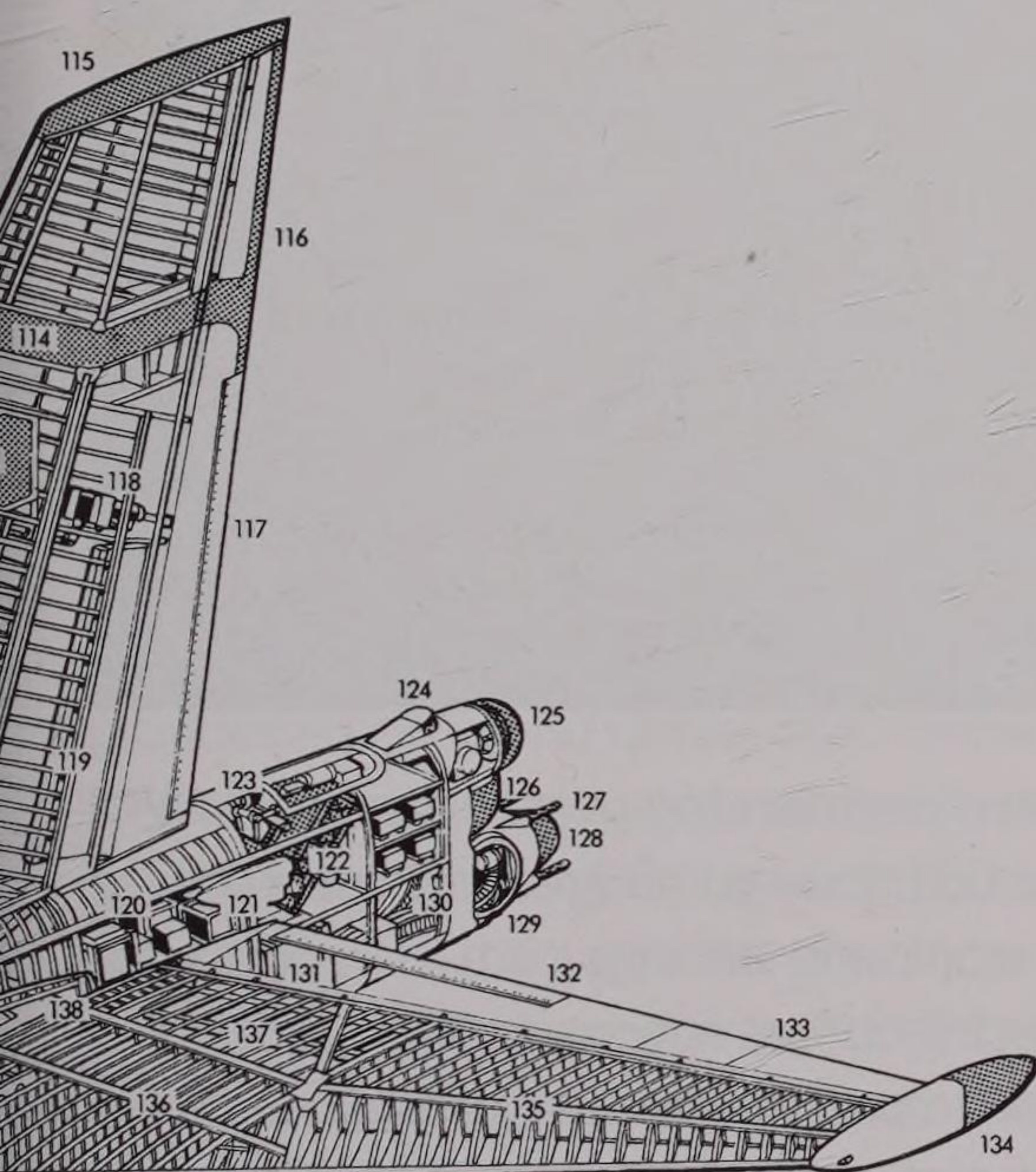
- 1 Nose radome
- 2 ALT-28 ECM antenna
- 3 Electronic countermeasures (ECM) equipment bay
- 4 Front pressure bulkhead
- 5 Electronic cooling air intake
- 6 Bombing radar
- 7 Low-light television scanner turret (EVS system), infra-red on starboard side
- 8 Television camera unit
- 9 ALQ-117 radar warning antenna
- 10 Underfloor control runs
- 11 Control column
- 12 Rudder pedals
- 13 Windscreen wipers
- 14 Instrument panel shroud
- 15 Windscreen panels
- 16 Cockpit eyebrow windows
- 17 Cockpit roof escape/ejection hatches
- 18 Co-pilot's ejection seat
- 19 Drogue chute container
- 20 Pilot's ejection seat

- 21 Flight deck floor level
- 22 Navigator's instrument console
- 23 Ventral escape/ejection hatch, port and starboard
- 24 Radar navigator's downward ejection seat, navigator to starboard
- 25 Access ladder and hatch to flight deck
- 26 EWO instructor's folding seat
- 27 Electronics equipment rack
- 28 In-flight refuelling receptacle, open
- 29 Refuelling delivery line
- 30 Electronic warfare officer's (EWO) ejection seat
- 31 Rear crew members escape/ejection hatches
- 32 EWO's instrument panel
- 33 Gunner's remote control panel
- 34 Gunner's ejection seat
- 35 Navigation instructor's folding seat
- 36 Radio and electronics racks
- 37 Ventral entry hatch and ladder
- 38 Lower deck rear pressure bulkhead
- 39 ECM aerials
- 40 ECM equipment bay
- 41 Cooling air ducting
- 42 Upper deck rear pressure bulkhead

- 43 Water injection tank, capacity 1,200 US gal (4,542 litres)
- 44 Fuselage upper longeron
- 45 Astro navigation antenna
- 46 Tank access hatches
- 47 Leading edge 'strakelets' fitted to identify cruise missile carriers
- 48 Forward fuselage fuel tank
- 49 Air conditioning plant
- 50 Forward starboard main undercarriage bogie
- 51 Landing lamp
- 52 Forward port main undercarriage bogie
- 53 Torque scissor links
- 54 Steering jacks
- 55 Main undercarriage door
- 56 Main undercarriage leg strut
- 57 Wing front spar/fuselage/main undercarriage attachment frame
- 58 Main undercarriage wheel bay
- 59 Doppler aerial
- 60 Central electronic equipment bay
- 61 Air conditioning intake duct
- 62 Front spar attachment joint
- 63 Wing root rib
- 64 Wing panel bolted attachment joint
- 65 Centre section fuel tank bay
- 66 Wing centre section carry-through
- 67 Starboard wing attachment joint
- 68 Vortex generators
- 69 Starboard wing integral fuel tank bays; total fuel system capacity (includes external tanks), 48,030 US gal (181,813 litres)
- 70 Engine ignition control unit
- 71 Bleed air ducting
- 72 Starboard engine nacelles



- 73** Nacelle pylons
- 74** Fixed external fuel tank, capacity 700 US gal (2,650 litres)
- 75** Tank pylon
- 76** Fuel venting channels
- 77** Tip surge tank
- 78** Starboard navigation light
- 79** Wing tip fairing
- 80** Fixed portion of trailing edge
- 81** Starboard outrigger wheel, stowed position
- 82** Hydraulic equipment bay
- 83** Roll control spoiler panels, open
- 84** Outboard single-slotted, Fowler-type flap, down position



- 85** Inboard fixed trailing edge segment
- 86** Chaff dispensers and flare launchers
- 87** Inboard single slotted flap, down position
- 88** Flap guide rails
- 89** Flap screw jacks
- 90** Flap drive torque shaft
- 91** Life raft stowage
- 92** Wing centre section/longeron ties
- 93** Central flap drive motor
- 94** Rear spar attachment joint
- 95** AGM-69 missile environmental control unit
- 96** Bomb bay rotary missile launcher
- 97** AGM-69 SRAM, air to ground missiles
- 98** Bomb bay rear bulkhead
- 99** Rear fuselage bag-type fuel tanks
- 100** Rear fuselage longeron
- 101** Fuel delivery and transfer piping
- 102** Fuselage skin panelling
- 103** Fuselage fuel system surge tank
- 104** Data link antenna
- 105** Rear fuselage frame construction
- 106** Rear equipment bay air conditioning plant
- 107** Ram air intake
- 108** Starboard tailplane
- 109** Vortex generators
- 110** Starboard elevator
- 111** Fin spar attachment joint: fin folds to starboard
- 112** Tailfin rib construction
- 113** VOR aerial
- 114** Lightning isolator
- 115** Fin tip aerial fairing
- 116** Rudder
- 117** Rudder tab
- 118** Hydraulic rudder control jack
- 119** Rudder aerodynamic balance
- 120** Rear ECM and fire control electronics pack
- 121** ECM aerial fairing
- 122** Brake parachute stowage
- 123** Parachute and door release mechanism
- 124** ALQ-117 retractable aerial fairing
- 125** AN/ASG-15 search radome
- 126** ALQ-117 and APR-25 ECM radome
- 127** Four 0.5-in (12.7-mm) machine-guns
- 128** AN/ASG-15 tracking radome
- 129** Remote control gun turret
- 130** Ammunition feed chutes
- 131** Ammunition tanks, 600 rounds per gun
- 132** Elevator tab
- 133** Port elevator
- 134** ALQ-153 tail warning radar
- 135** All-moving tailplane construction
- 136** Tailplane carry-through box-section spar
- 137** Elevator aerodynamic balance
- 138** Centre section sealing plate
- 139** Tailplane trimming screw jack
- 140** Air conditioning ducting
- 141** Fuel system venting pipes
- 142** Ventral access hatch
- 143** Rear fuselage ECM equipment bay
- 144** ECM aerials
- 145** Strike camera compartment
- 146** Rear main undercarriage wheel bay
- 147** Bomb/wheel bay box-section longeron
- 148** Main undercarriage mounting frame
- 149** Hydraulic retraction jack
- 150** Rear main undercarriage bogie units
- 151** Flap shroud ribs
- 152** ECM dispensers
- 153** Fixed portion of trailing edge
- 154** Port flaps, down position
- 155** Outboard single slotted flap
- 156** Port roll control spoiler panels
- 157** Hydraulic reservoir
- 158** Outrigger wheel bay
- 159** Fixed portion of trailing edge
- 160** Glass-fibre wing tip fairing
- 161** Port navigation light
- 162** Outer wing panel integral fuel tank
- 163** Port outrigger wheel
- 164** Fixed external fuel tank
- 165** Fuel tank pylon
- 166** Outrigger wheel retraction strut
- 167** Outer wing panel attachment joint
- 168** Engine pylon mounting rib
- 169** Pylon rear attachment strut
- 170** Engine pylon construction
- 171** Pratt & Whitney J57-P-43WB turbojet engine
- 172** Engine oil tank, capacity 8.5 US gal (32 litres)
- 173** Accessory equipment gearbox
- 174** Generator cooling air duct
- 175** Oil cooler ram air intakes
- 176** Engine air intakes
- 177** Detachable cowl panels
- 178** Leading-edge rib construction
- 179** Front spar
- 180** Wing-rib construction
- 181** Rear spar
- 182** Port wing integral fuel tank bays
- 183** Inboard pylon mounting rib
- 184** Leading-edge bleed air and engine control runs
- 185** Weapons bay doors, open (loading) position
- 186** Bomb doors, open
- 187** Wing-mounted cruise missile pylon
- 188** Boeing AGM-86B Air Launched Cruise Missiles (ALCM), six per wing pylon, stowed configuration
- 189** AGM-86B missile in flight configuration
- 190** Retractable engine air intake
- 191** Folding wings
- 192** AGM-69 SRAM, alternative load
- 193** Missile adapters
- 194** Nacelle pylon
- 195** Port inboard engine nacelles
- 196** Central engine mounting bulkhead/firewall
- 197** Bleed air ducting
- 198** Generator cooling air ducting
- 199** Fuselage bomb mounting cradle
- 200** Free-fall 25-megaton nuclear weapons (four)



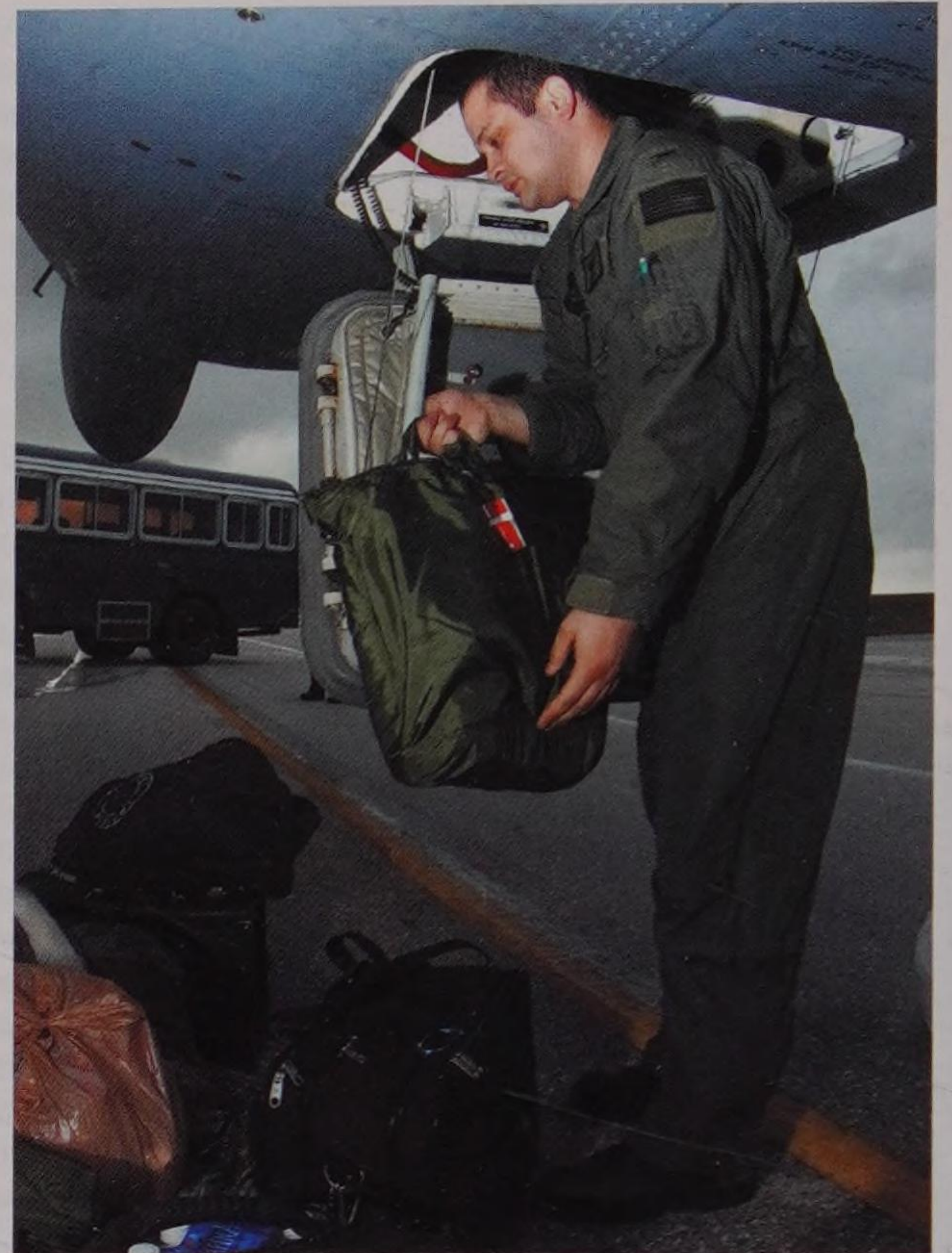
ABOVE AND RIGHT
The crew entry hatch is located forward of the front landing gear. It hinges forward and is attached to two steel support cables.
(USAF)

hinged, grated door covers the entrance between the two decks.

During flight a 'crawlway' enables movement through the equipment deck, forward wheel well, bomb bay, aft wheel well and aft equipment compartment. This extends from the pressure bulkhead door in the crew compartment aft pressure bulkhead, to the aft equipment compartment.

Engine bleed air is used to create an air supply for air conditioning and anti-icing, while primary electrical power is 205V AC supplied by four engine-driven generators. Six engine-driven hydraulic pumps and two electric motor-driven hydraulic pumps create hydraulic pressure for various aircraft systems.

Pitch and yaw control is provided by hydraulically actuated rudder and elevators, while lateral control is maintained by means of hydraulically actuated spoilers. Meanwhile, pitch trim is accomplished by hydraulically moving the entire horizontal stabiliser. A steering and crosswind crab system provides steering of



the forward main landing gear. It also properly positions both forward and rear main landing gear for crosswind landings.

An electro-optical viewing system (EVS) is installed to provide pilots and navigators with a view of the area ahead of the aircraft. Used during both day and night missions, the EVS boasts optical and infrared cameras. For navigation, an embedded GPS receiver suite provides position updates and feeds data to a moving map display.

For robust communications, an Air Force satellite communications system (AFSATCOM)

RIGHT The Stratofortress can carry an impressive number and variety of conventional and nuclear weapons. Here, a selection of conventional stores cleared for carriage is showcased in front of a B-52H at Barksdale AFB, Los Angeles.
(USAF)



terminal is installed. It features a UHF terminal that provides communications capability in both line-of-sight and satellite modes. Meanwhile, text messages can be received and sent via a dual modem known as the airborne miniature receive terminal (MRT), or AN/ARR-85(V).

The MRT operates within the VLF/LF bands and prints secure and non-secure messages received over extended ranges.

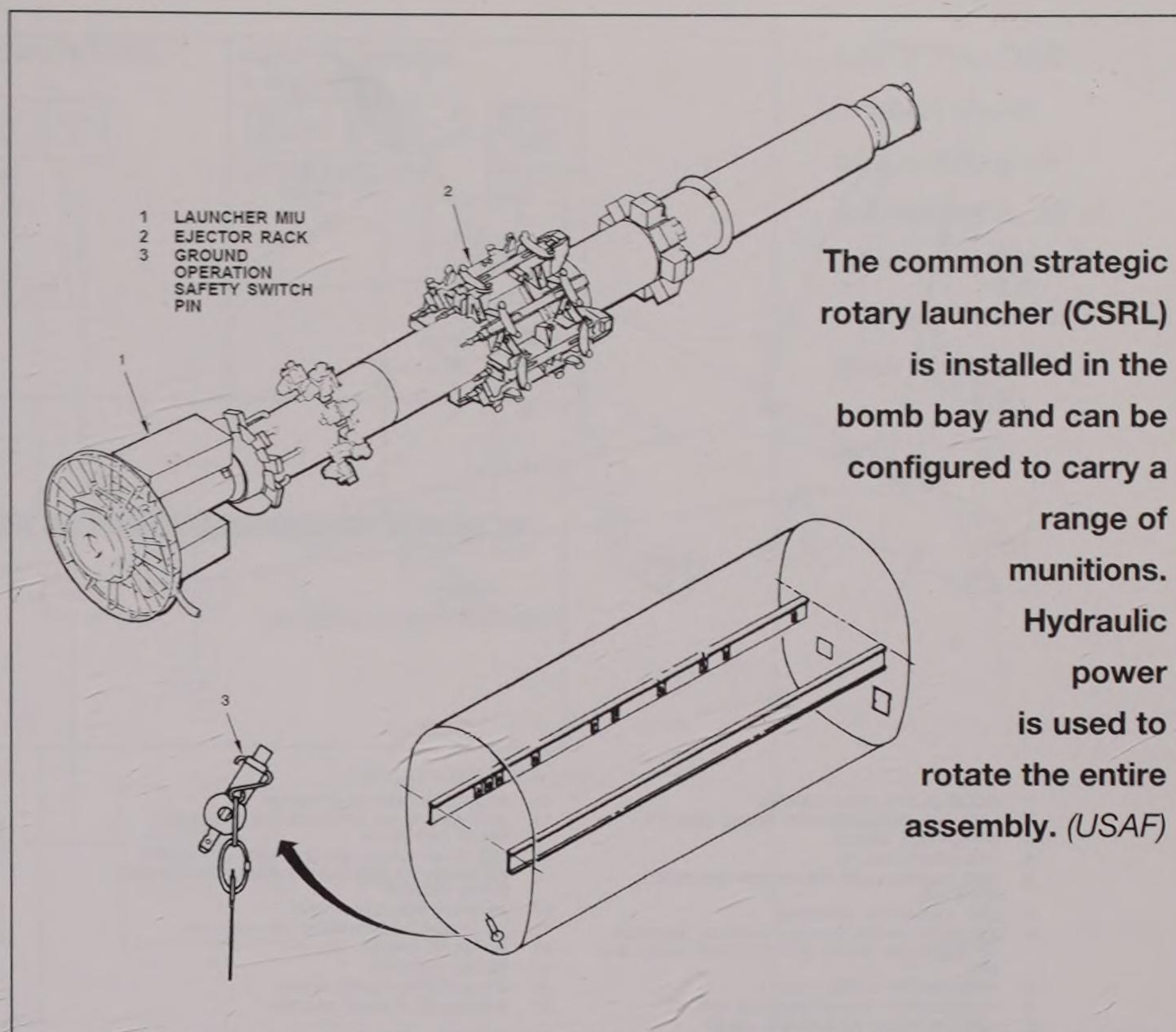
Given the highly diverse range of missions that the B-52H can be tasked to execute, it is no surprise that a highly variable weapons load may be carried. The weapon/missile equipment interfaces with the AN/ASQ-176 offensive avionics suite (OAS), AN/APN-224 radar altimeter, and the aircraft electrical, bleed air and hydraulic systems.

Inside the Stratofortress' bomb bay, a hydraulically driven revolver-type launcher – the common strategic rotary launcher (CSRL) – provides umbilical and ejector rack connections for both conventional and nuclear weapons. The navigators may employ these weapons either automatically or manually. The aircraft can carry a variety of gravity weapons suspended internally on three cluster rack assemblies, permitting the internal carriage of up to 27 weapons in total.

External pylons can carry external munitions or sensors. There are three basic external configurations: 1) up to 12 cruise missiles may be carried; 2) 24 weapons carried when an 'AGM-28 pylon' is installed under each wing; and 3) a heavy stores adapter beam (HSAB) can be attached to the stub pylon on each wing and up to nine MAU-12 bomb racks can be attached to each HSAB for a total external carriage capability of up to 18 weapons. (See Appendix for more information on weapons carriage and configurations.)

RIGHT A wide array of loaders is available to get the B-52H's impressive array of compatible stores on to the external pylons or into the bomb bays.

Even so, when an ORI (operational readiness inspection) team comes to town speed can make the difference between a pass and fail, and brute force can sometimes play its part. In this case, two weapons loaders push a dolly loaded with inert SRAM missiles (pre-loaded on to a pylon and stored inverted). (USAF)



LEFT The HSAB – heavy stores adapter beam – attaches to a stub pylon on the B-52's wing. Here, a Quickstrike mine is loaded on to one of the nine MAU-12 adapters installed on each HSAB. (USAF)



Navigation equipment – navigation and computational subsystems

The B-52 is a central element of the US Air Force's 'Global Reach' policy – it must be able to autonomously navigate to and from any target in the world in order to employ either conventional or nuclear munitions. Its navigation system is therefore highly sophisticated, allowing accurate flight over great distances, and permitting very precise targeting of onboard weapons. A GPS inertial navigation system forms the heart of this capability in the B-52H, while TACAN (tactical air navigation) and omni-range radio systems provide additional navigation capability and redundancy in case of loss of the GPS.

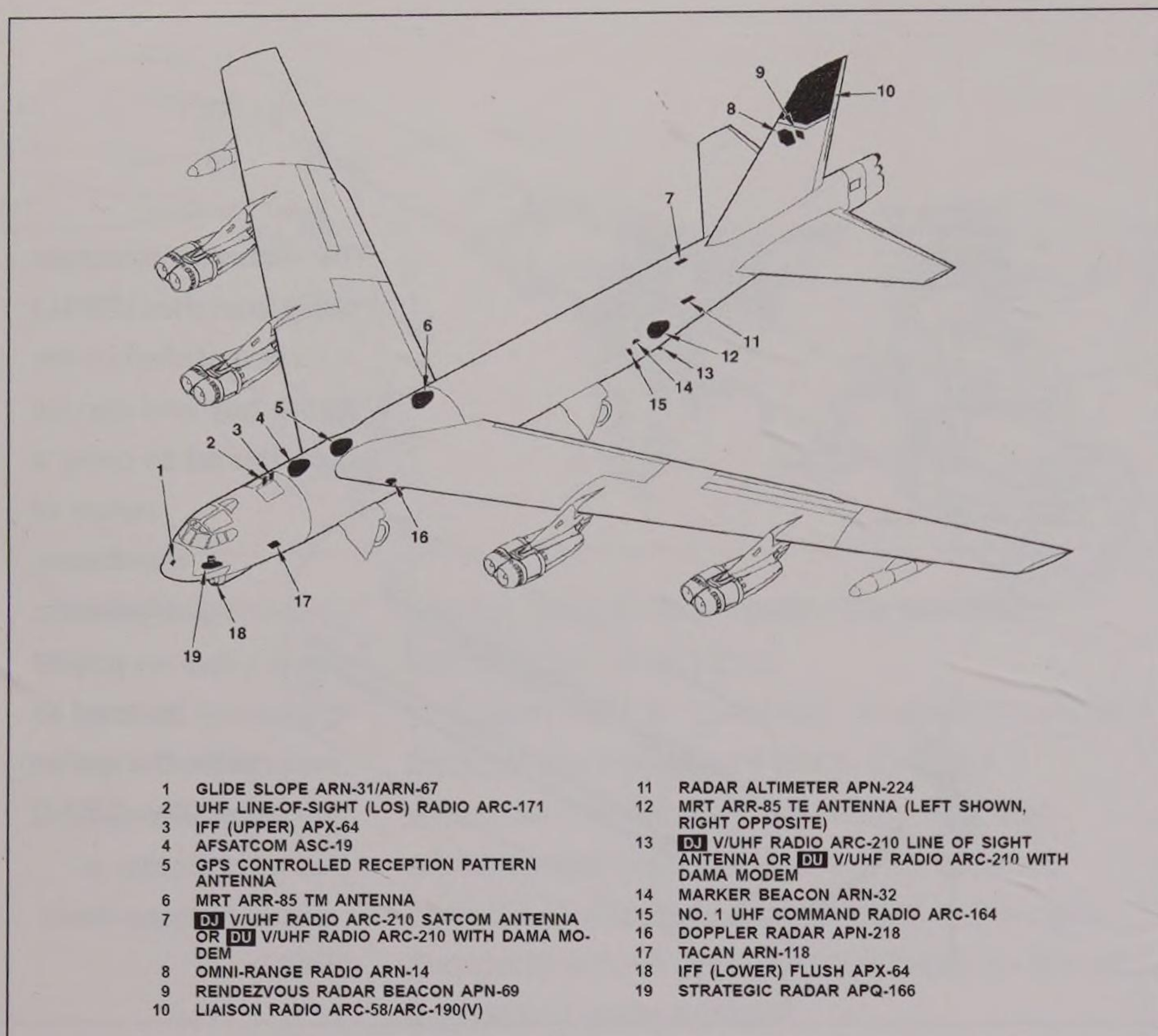
Collectively, the B-52H's navigation systems belong to what is termed the AN/ASQ-176 offensive avionics suite. The OAS is a new system born from the Avionics Midlife Improvement (AMI) programme, and is characterised as 'a computer controlled suite of electronics that enables nearly automatic navigation and weapon delivery'. It comprises 11 systems categorised into five subsystems: navigation, computational, weapons control and delivery, interface, and controls and display.

The navigation subsystem incorporates the following:

- Inertial navigation set AN/ANS-136.
- Attitude heading gyroscope Set AN/ASN-134.
- Doppler radar navigation set AN/APN-218.
- Global positioning system (GPS) AN/ARN-151(V).
- Electronic altimeter set AN/APN-224 (radar altimeter).

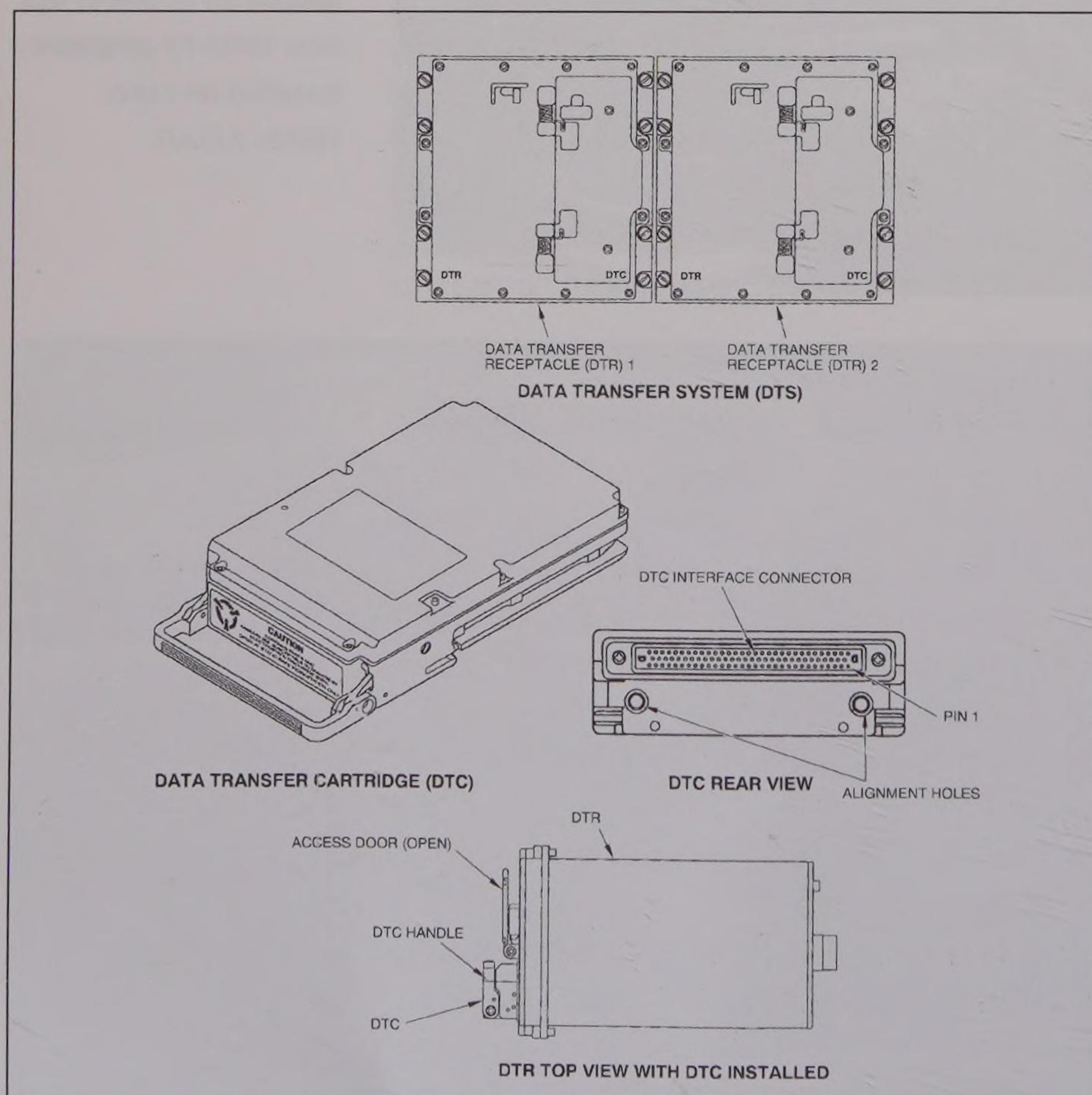
In addition to these key components, the B-52H is also equipped with an AN/ARN-118(V) TACAN radio, AN/ARN-14 Omni-range radio, instrument landing system (ILS), AN/ARN-31 or AN/ARN-67 glide slope receiver, AN/ARN-32 beacon receiver, and AN/APX-64 IFF (identification friend or foe) transponder set.

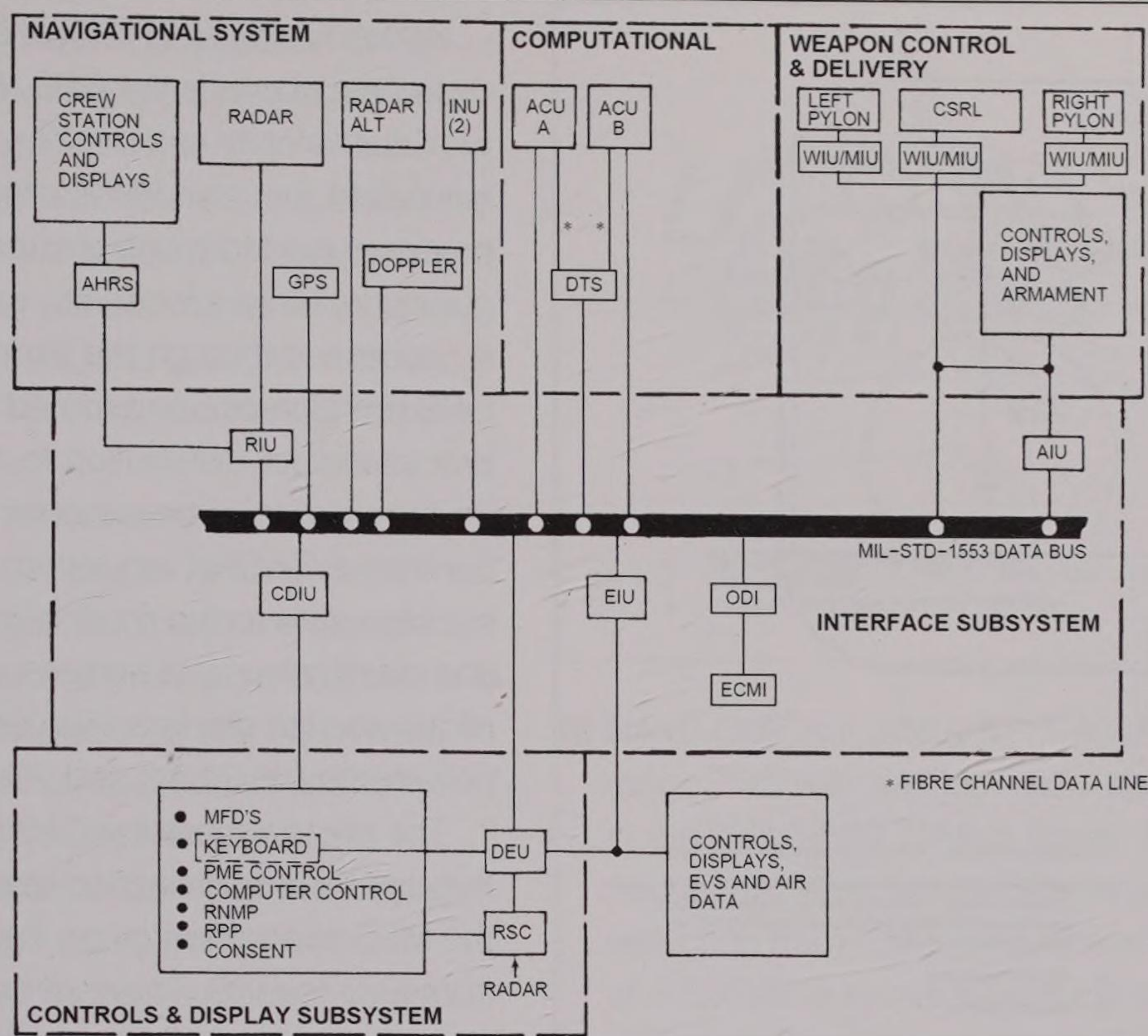
Each of the OAS components is managed by avionics computers (ACUs) that are controlled by



ABOVE The antennae for the B-52's navigation and communications suite are spread across 19 locations that span from nose to tail. (USAF)

BELOW The data transfer cartridge – sometimes known as the 'brick' – transfers the entire mission planning data into the OAS. The cartridge is about the size of a small external computer hard drive. (USAF)





LEFT The OAS is comprised of a number of subsystems, all of which are linked by a military standard 1553 data bus. (USAF)

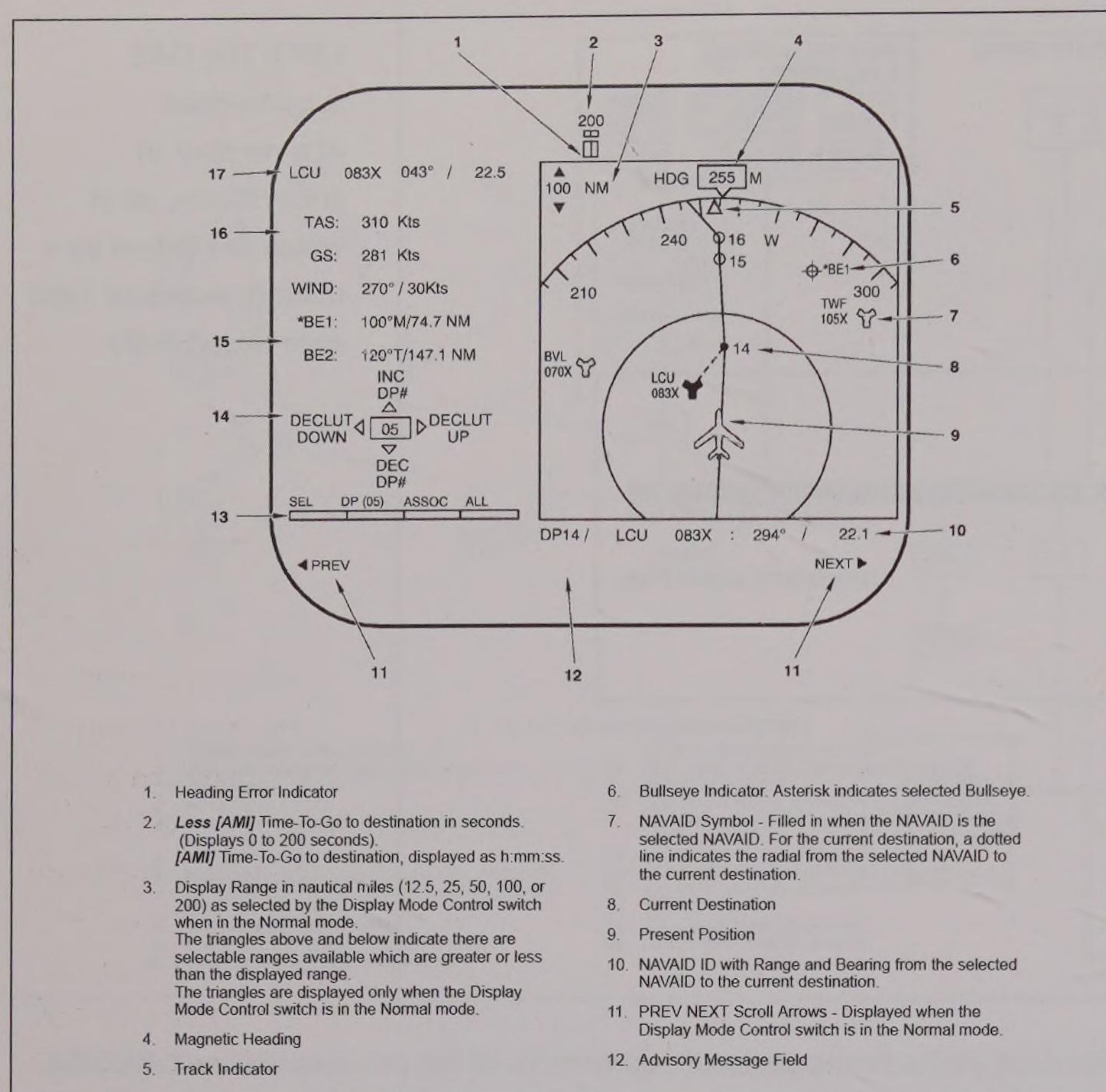
a flight computer program (FCP) linked by a MIL-STD-1553 data bus. The FCP is a software suite that can be updated with ease, while the 1553 bus is a set of hardware that carries information between the ACUs. Together they confer a great deal of automation, cutting operator workload and helping to eliminate operator error.

Except for the AN/ASN-134 attitude heading reference system (AHRS) and AN/APN-224 radar altimeter systems, the OAS is controlled from the navigator and radar navigator's stations. In use, the navigation subsystem is loaded with the desired FCP, as well as mission data, target data and missile data before take-off. The latter three sets of data can be loaded manually, although it is more typical to use the data transfer cartridge (sometimes called a 'brick') to download information from the crew's mission-planning computers. The brick is simply inserted into a receptacle at the navigator's station, following which the data is automatically downloaded into the OAS. Two receptacles exist, one for each navigator.

Once the DTC process is accomplished, the navigators can align the navigation system to a known position (*ie* their parking spot), after which the OAS will provide steering commands to fly towards programmed destinations. It also provides steering to programmed missile and weapon release points. All of this actually occurs

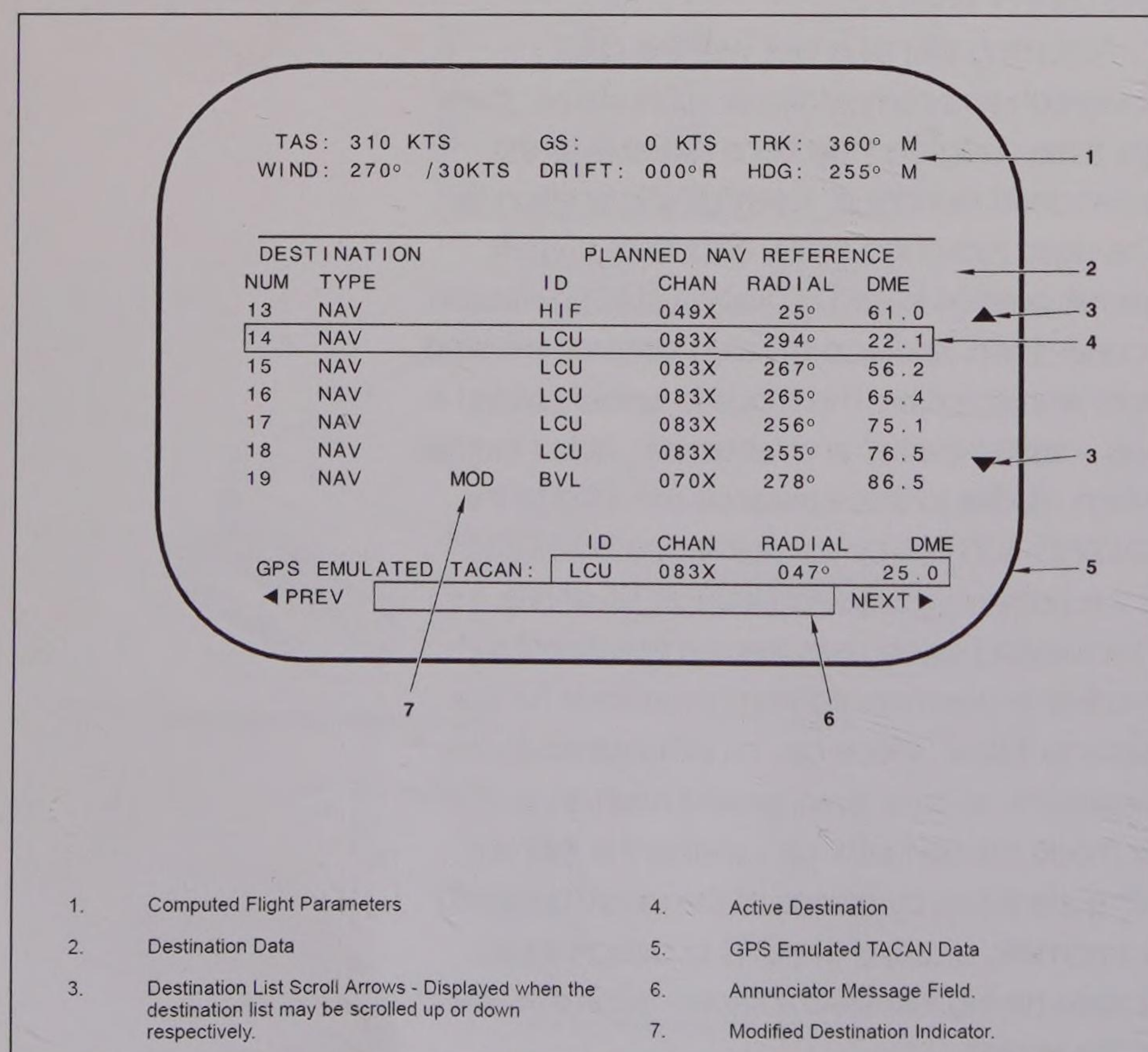
courtesy of the computational subsystem, which consists of the data transfer system, two ACUs and data buses already described above, and a fibre channel data line. In effect the computational subsystem is the brain of the OAS and performs all calculations needed for navigation and weapon delivery, all coding, decoding and transmission/receiving of data, and all systems management and control functions.

Assuming that all is well with the OAS' navigation and computational subsystems, there are three navigation functions available to the crew: dead reckoning, steering, and position fix. The dead reckoning facility calculates current aircraft position based on known starting position, course flown, and accumulated distance travelled from starting point. This mode is further divided in two – 'aided-inertial' and 'alternate'. Aided-inertial, which alludes to the assistance provided to the AN/ANS-136 INS by the AN/ARN-151(V) GPS, is the primary option used in most situations. The steering mode uses the computational submodule to generate steering commands for the pilots to follow. These can be either direct to the steerpoint, or on a given ground track. In position fix mode the navigator can update the INS and eliminate errors by means of the radar, overflying a landmark, or using the EVS to designate an update having identified a known landmark ahead of the aircraft.



ABOVE The mission route screen combines with a moving map display and is fed data from the electro-optical viewing system and the GPS. (USAF)

BELOW The destination data screen displays alphanumeric text that provides the crew with all of the mission steerpoints and associated data. (USAF)



At the heart of the navigation functionality described above is the GPS. It not only provides velocity and position data for navigation, but also feeds information to those precision-guided munitions that utilise GPS guidance. More specifically, satellite information is processed through the Stratofortress' GPS components and routed to the avionics processors for distribution to navigation and weapon delivery components. The GPS also controls a 'TACAN emulation' function and supplies data to the moving map displays and destination data screens displayed on the pilots' cockpit displays. The GPS avionics are all powered by 115V AC and 28V DC.

The pilots access the GPS navigation data through their multifunction displays by flipping the MFD control switch on their side panels from EVS to GPS. They are then presented with one of two selectable displays: mission route screen/moving map display, and the destination screen. The former includes all sorts of data, from nav aids and time-to-go calculations to the engagement envelope of onboard weapons. The latter provides nav aid data associated with the destination. GPS navigation and TACAN emulation data are also presented on the pilots' navigation instruments.

The two AN/ASN-136 inertial navigation sets installed in the B-52H are referred to as SPN/GEANS (standard precision navigation/gimballed electrically suspended gyro airborne navigation system). Each comprises an inertial measurement unit (IMU) and an interface electronic unit (IEU). The IMU contains a hollow beryllium rotor and ceramic suspension electrodes and associated circuitry. They each provide inertial reference and stabilisation of three accelerometers for measurement of aircraft motion. A rotor support power adapter provides power to support each IMU in the event AC power is lost for more than ten seconds, or both AC and DC power are lost. Ordinarily the INS is powered by 115V three-phase AC 400Hz power, but backup power comes courtesy of 28V DC. The INS is controlled by the computational subsystem software, and interfaced via the radar navigator and navigator keyboards and the OAS power control panel.

The AN/APN-224 radar altimeter system

is operated by the pilots and gives the OAS definitive altitude information during low altitude flight. The radar altimeters also tie in with the terrain avoidance system (see below), indicating the highest terrain within their 90° conical field of view. They do so without degradation at up to 45° of pitch and roll, and 2,200fps rate of climb or descent. They are accurate to within around 3ft.

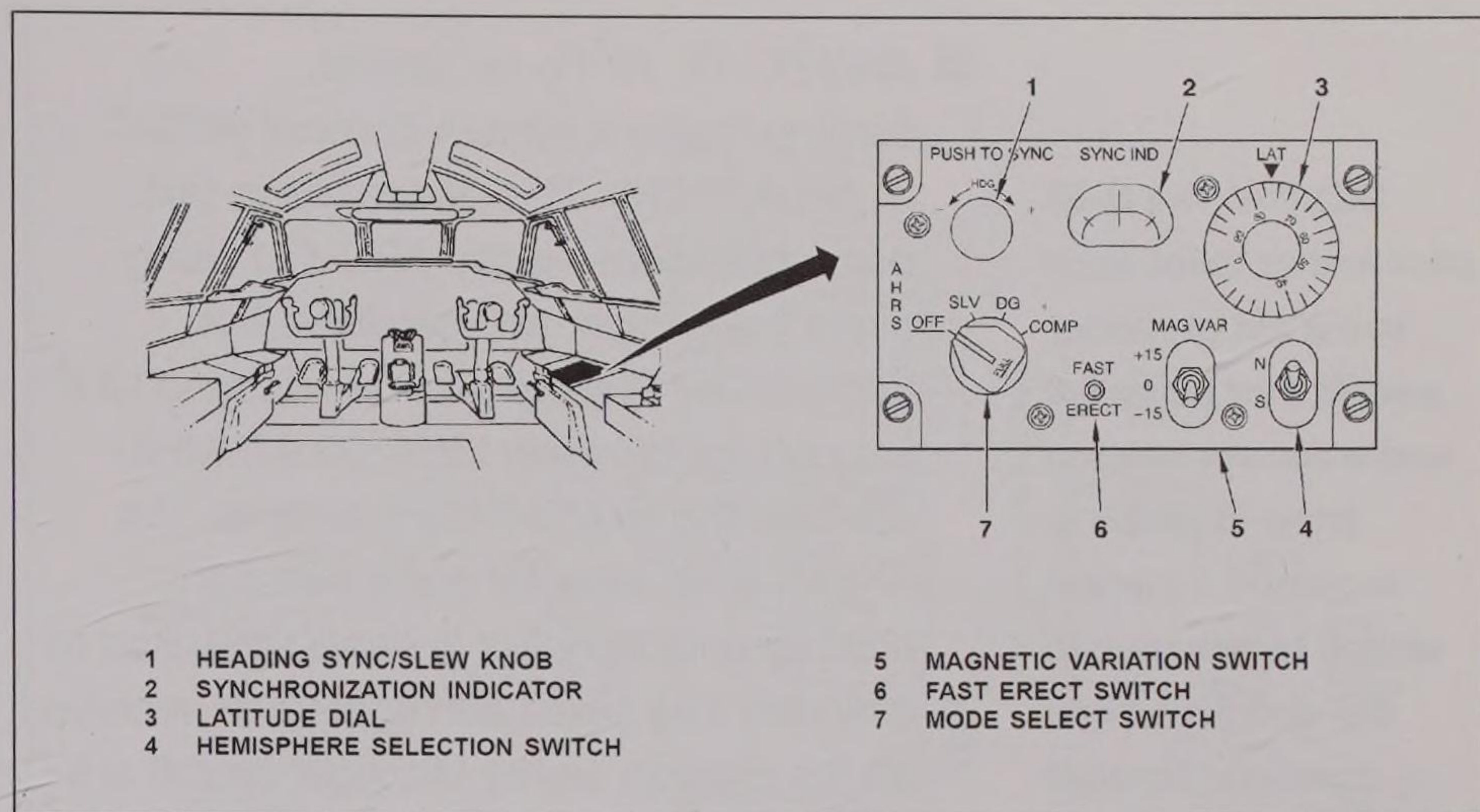
The AN/APN-218 radar navigation set is better known as the Doppler radar system. As its name suggests, it exploits the Doppler principle to determine aircraft ground speed and drift angle. This information is then displayed to the navigators as ground speed and drift correction angle. The Doppler antenna is installed on the lower centreline of the fuselage, forward of the bomb doors. Its controls and displays are located at the navigators' station.

The AHRS consists of an AN/ASN-134 attitude heading reference set, also known as the attitude heading gyroscope set. It is made up of an AHRS control panel located on the co-pilot's side panel, a gyro reference unit, an electronic control amplifier and a compass compensation unit. It provides heading, attitude and yaw information for use by the automatic flight control system (autopilot). While it can be operated in three modes it is standard to use a 'slaved' mode, whereby the AHARS is slaved to a magnetic azimuth detector to provide heading information. The AHRS uses 115V three-phase AC power, and becomes fully operational one minute after turn-on with accuracies of $\pm 1^\circ$ vertical for altitude and $\pm 0.5^\circ$ of heading output in the slaved mode. Slaved mode also provides a heading output through the OAS to the navigator's MFD, with accuracies of $\pm 1.1^\circ$.

Communication equipment

Given the vast distances that the B-52 can cover, not to mention the need to be able to dynamically target the enemy, the Stratofortress crew is provided with secure and jam-resistant communications equipment that is paramount in accomplishing the Global Reach mission.

In addition to the AN/AIC-18 interphone that allows all crew members to talk to one another, there are several other important systems:



■ HAVE QUICK II, AN/ARC-164(V), short range, two-way anti-jam radio operating in the 225.0–399.75MHz range. This radio frequency hops many times per second (selecting from 7,000 frequencies in steps of 0.025MHz) to make jamming extremely difficult. It has a range of up to 270 miles and is controlled from the pilots' overhead panel. The ARC-164 also has a 'guard receiver' that is pre-set to monitor guard on 243.000MHz.

■ AN/ARC-210(V) and MD-1333, VHF/UHF radio with DAMA. This is a short- and long-range, two-way anti-jam radio that uses encryption techniques to prevent eavesdropping. The ARC-210 operates within a frequency range of 30 to 399.9875MHz, tuneable at 5kHz intervals.

The DAMA (demand assigned multiple access) module uses satellite networks (either 5kHz or 25kHz) to relay the ARC-210's transmissions. The pilot controls the ARC-210, while the navigator controls the DAMA. Although the radio can transmit/receive data at up to 32,000 bits per second, this capability is not currently used.

As with the HQ II radio, the ARC-210's anti-jam capability is conferred via synchronised precision clocks and programmable frequency switching patterns. The ARC-210 and DAMA are not installed in all B-52Hs – see ARC-171 below.

■ AN/ARC-190(V) long-range, two-way voice and data communications liaison radio, controlled from the co-pilot's right-hand console. It provides long-range voice communications in the high frequency range, 2.0000–29.9999MHz in 100Hz steps (280,000 available frequencies).

ABOVE The AHRS controls are located on the co-pilot's side console. Also known as the attitude heading gyro set, it supplies information to the automatic flight control system. (USAF)

BELOW The B-52 pilot and co-pilot each use a set of rudder pedals (not pictured) and a control column (atop of which is mounted a control wheel) to manipulate the aircraft's flight controls. Fore/aft movement of the column controls pitch attitude, while left/right movement of the wheel controls roll. A disconnect lever for the control column allows it to be stowed in the fully forward position, allowing greater room for the 'pilot not flying' during extended operations. (USAF)

■ AN/ASC-19, Air Force satellite communications system terminal (AFSAT or AFSATCOM). This device relays text communications via the ARC-171 using direct line of sight with satellites. It is operated by teletype over narrowband UHF frequencies between 225–399.975MHz, selectable in 0.025MHz increments. The AFSAT does allow for some wideband (25kHz) operation, but is generally limited to channels that have been specifically reserved for the mission. Some H-model aircraft are also equipped with a dual modem. Both devices are controlled by the navigator, and received messages are printed out by an AFSAT printer at the navigator's station.

■ AN/ARR-85(V) miniature receive terminal, installed in the navigator's station. This is a long-range, receive-only data communications device capable of receiving transmissions at distances of up to 1,500 miles. It operates in VLF/LF frequencies and automatically receives, processes and prints secure and non-secure messages. It is intended to operate at extended ranges in nuclear and communications jamming

environments over the frequency band of 14–60KHz, selectable in 10Hz increments. It has its own printer, designated RP-346, filled with 25ft of 2.4in-wide thermal paper.

■ KY-100 secure voice radio, which encrypts analogue plain voice and decrypts ciphered voice transmissions from/to the command radio – either the ARC-164 HQ II, or the ARC-210 – depending on which the crew have assigned as the 'UHF-1' command radio on their control panels.

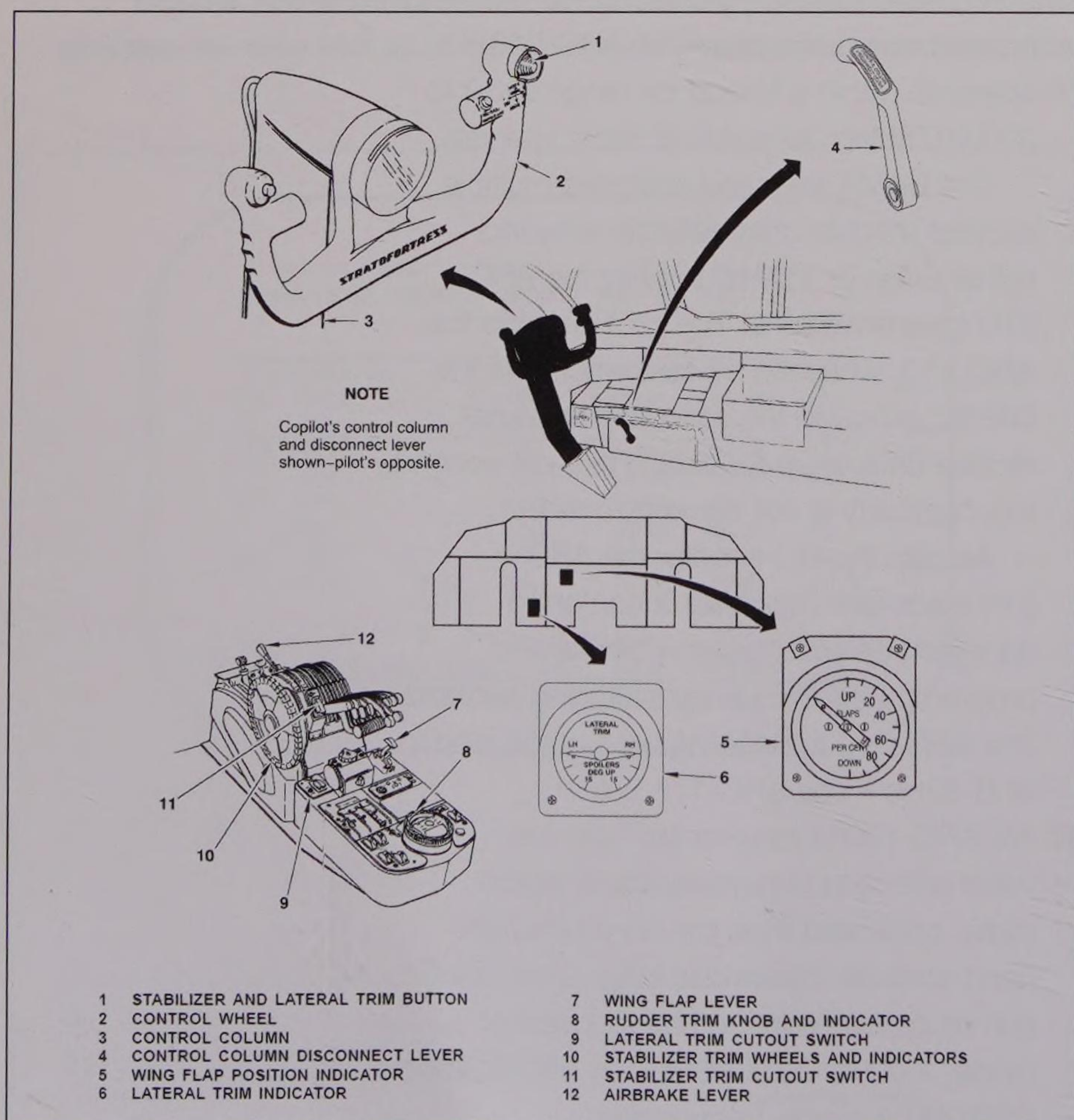
■ The AN/ARC-171(V) UHF radio is installed in those B-52s not equipped with the ARC-210. It has 7,000 frequencies available in steps of 0.025MHz within the frequency range of 225.0–399.975MHz. The ARC-171 is controlled by either the navigator or pilot (control panel locations vary among the B-52 fleet).

Flight control systems

The B-52H is flown by means of three basic primary control systems – elevator, rudder and lateral control. The elevators and rudder are moved by two hydraulic circuits (left and right), while lateral control comes not from ailerons but from spoilers that are deployed hydraulically and controlled mechanically. The hydraulically powered rudder/elevator system is coupled to a yaw and pitch stability augmentation system (SAS) which provides roll damping, helps reduce structural loads and aids controllability in turbulence. The SAS and mechanical command ability (ie pilot inputs to the control yoke and rudder pedals) will remain fully operational even in the event that one of the two hydraulic systems fails.

The rudder is moved by a single actuator, and the maximum rudder deflection is limited to $\pm 19^\circ$ for pilot-commanded control inputs and $\pm 10^\circ$ for SAS inputs. The rudder pedals have an artificial feel system incorporated, which consists of a 'Q spring' installed in the cable system to simulate the aerodynamic loads that would be felt in a conventional pulley and cable rudder system. A ball bearing screw actuator attached to the cable system allows the pilots to trim the rudder via a rudder trim knob located on the aisle stand between them.

Two elevator actuators – one per side, each acting independently of the other – provide



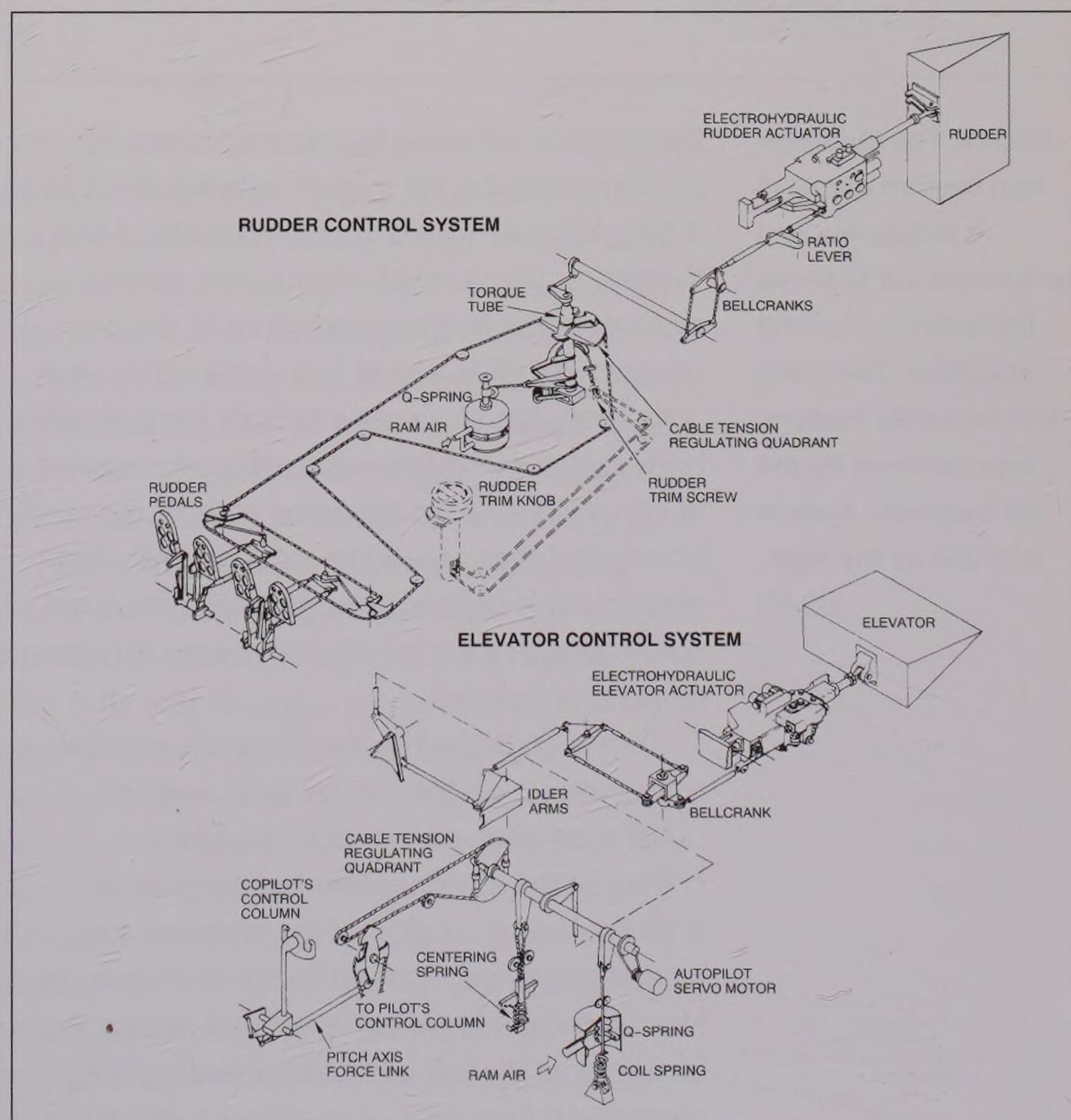
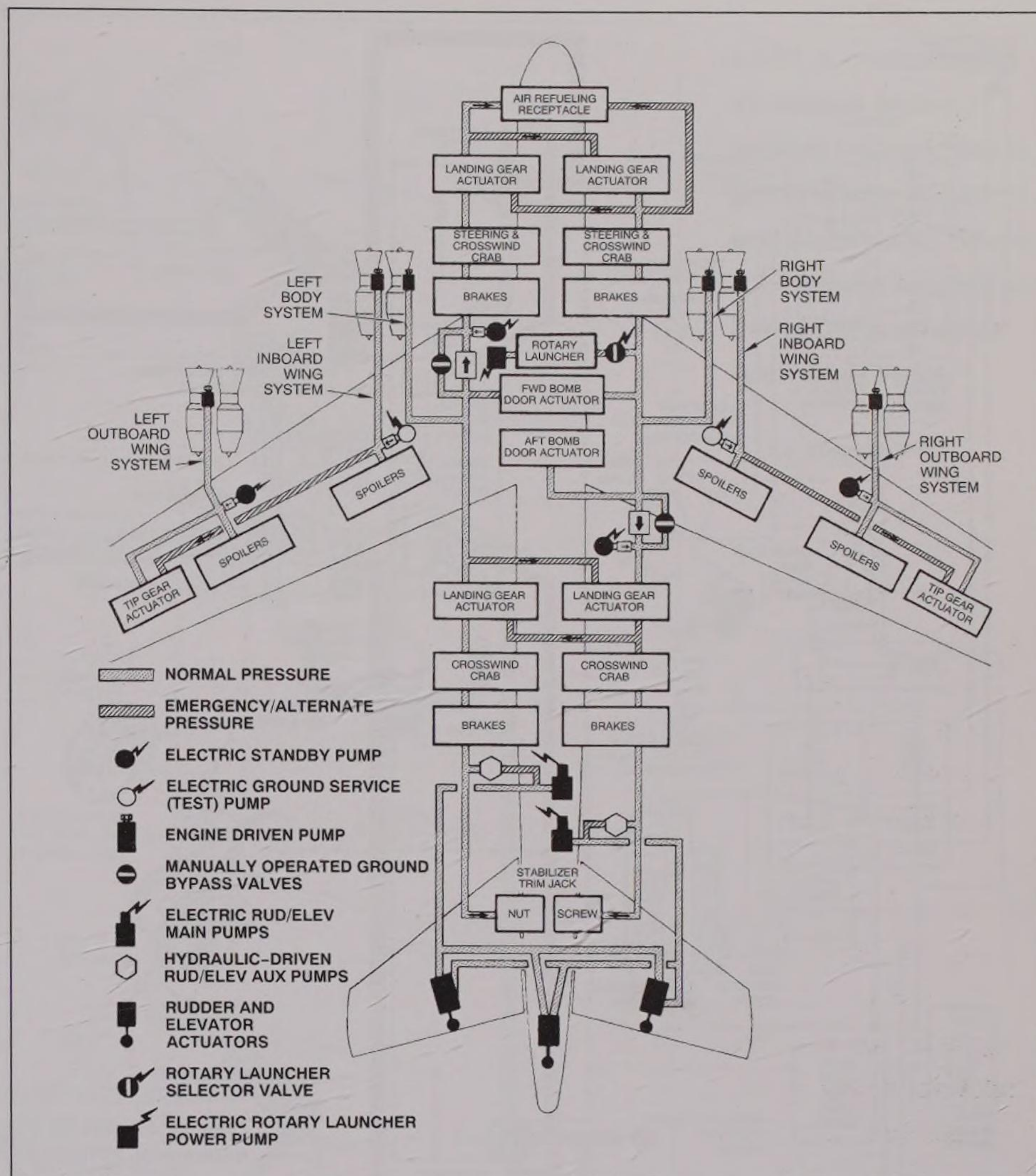
RIGHT A schematic of the B-52's hydraulic flight control systems showing the location of flight control surfaces and their associated hydraulic pumps, standby pumps and auxiliary pumps. (USAF)

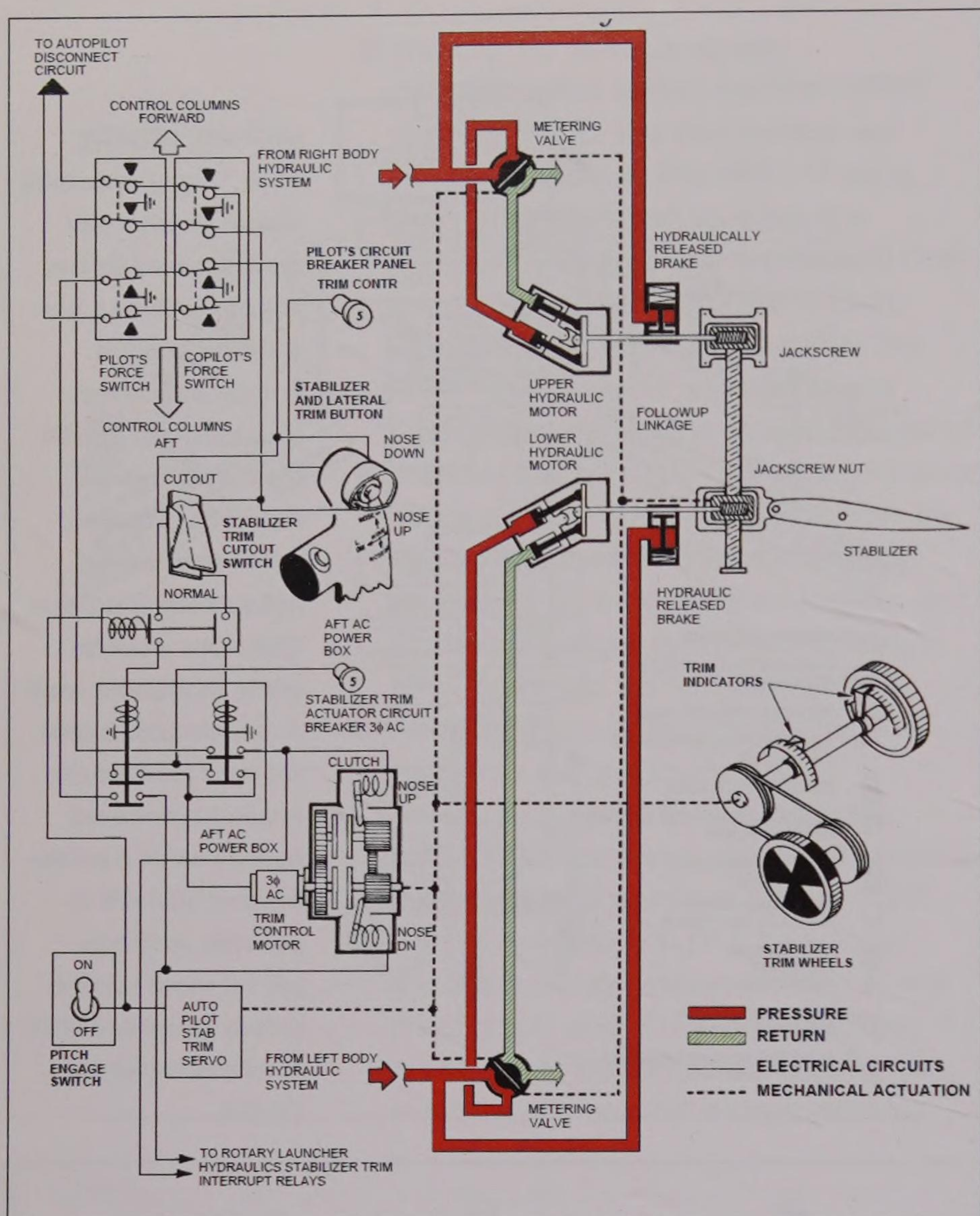
pitch axis control. They position the elevators in response to pilot control inputs on the control yoke, autopilot pitch axis inputs, and electrical signals transmitted from the SAS. Electrical commands from the SAS are transmitted to an electromechanical flow control valve that operates in series with the pilot commands. The control columns transmit control movements to the elevators via fore and aft movement. The maximum elevator deflection is $\pm 19^\circ$ for pilot control inputs and approximately $\pm 5^\circ$ for SAS inputs.

Like the rudder, elevator feel and centring is provided by a Q spring and a mechanical spring in the cable system. The Q spring is a single bellows chamber that has a preloaded mechanical spring to provide control-centring force in the low-speed range. Movement of the control column fore or aft from neutral is immediately opposed, thus providing supplemental artificial feel and positive control. The configuration does three things: the effort required to manoeuvre the aircraft in pitch at low airspeeds is increased, thereby encouraging use of trim; the effort required is decreased at high airspeeds, thereby providing improved manoeuvring capabilities; and at all airspeeds there is a positive centring force that increases trim stability.

The B-52H does not have conventional elevator trim or trim tabs. Instead, pitch trim is accomplished by hydraulically moving the entire stabiliser (horizontal tail). The leading edge of the stab is raised and lowered by a jackscrew driven by two hydraulic motors: one drives the screw and the other the nut. The motor driving

RIGHT The rudder and elevator control systems are hydraulically powered and incorporate electrohydraulic actuators and Q-springs. The latter creates a simulated feel of the aerodynamic loads that might otherwise be present in a more simple cable-and-pulley control system. (USAF)





ABOVE The stabiliser trim system employs a jackscrew and jackscrew nut to move the entire horizontal stabiliser. There are two hydraulic motors, one powered by the left hydraulic system and one by the right. (USAF)

the screw is powered by the right hydraulic system, while the left system supplies the motor driving the nut. Valves controlled by the cable system, or by a parallel electric trim control system, meter hydraulic pressure to the two motors. Stabiliser speed is approximately four units every ten seconds with both left and right body hydraulic systems operating and engines at idle. With engines operating at 82% rpm and above, this is increased to six units every ten seconds. It is noteworthy that pitch trim is not automatically adjusted when the wing flaps are raised and lowered.

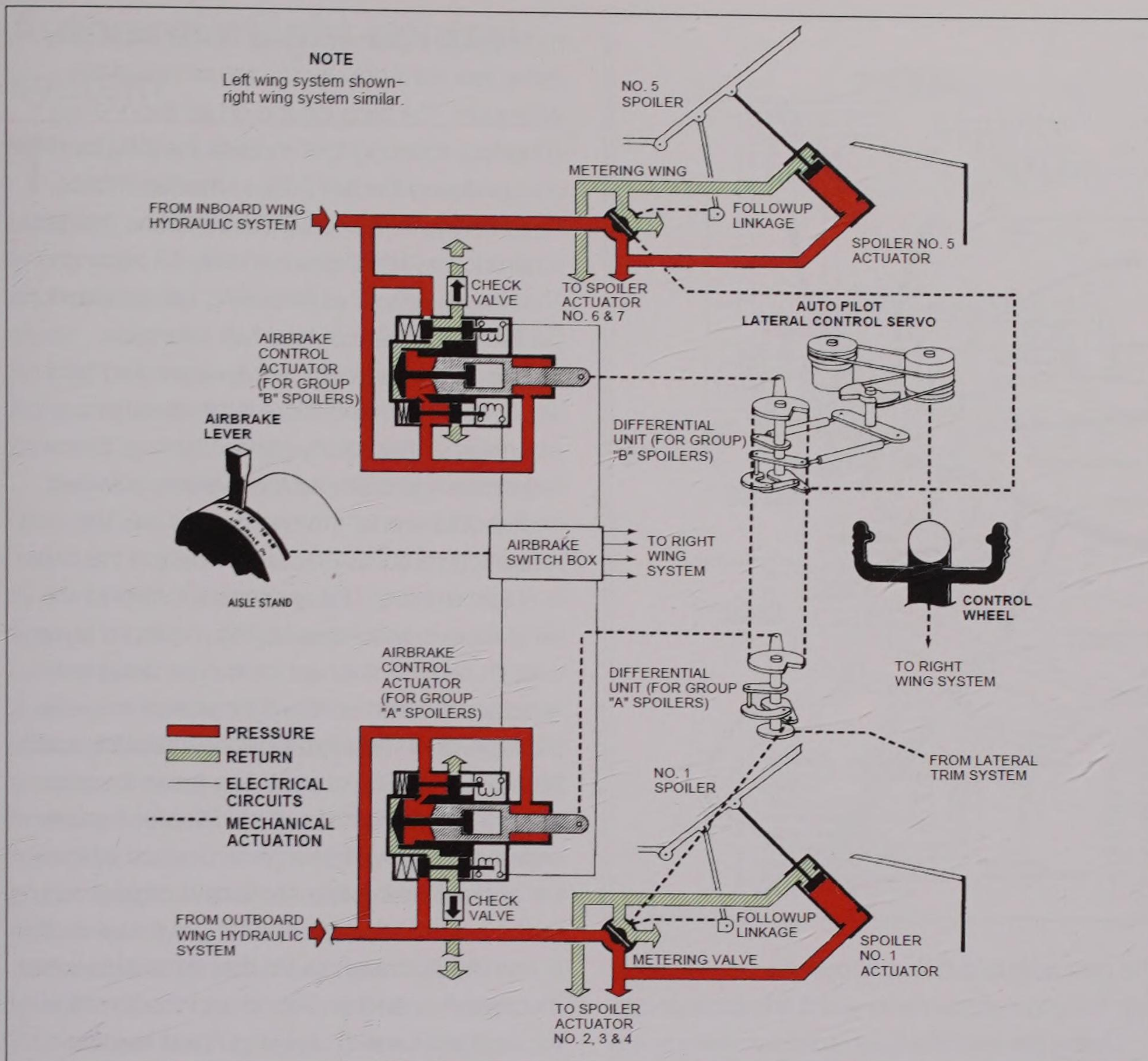
Trim is controlled by two means – manual rotary wheels on the control aisle, and trim buttons on each control column. Manual control of the stabiliser trim-metering valve is prompted by rotation of the stabiliser trim wheels connected to a chain sprocket linkage. Next to the pilot's wheel is a trim indicator that is calibrated in units of stabiliser leading edge movement, from nine units of 'nose down'

to four units of 'nose up'. One unit equals 1° of stabiliser travel. The electric trim control system actually feeds back through the cable system, rotating the manual trim wheels and indicators in turn. Where a conflict between the two systems exists the mechanical system will override the electrical one.

Two systems protect against uncommanded, or 'runaway', trim conditions. First, a guarded stabiliser trim cut-out switch on the aisle stand can be used to disconnect the DC control circuits between the trim buttons and the stabiliser trim control relay coil. This switch does not affect manual control of stabiliser trim. Second, each control column linkage features 'force switches' that detect an opposing force between the pilot's control inputs and the trim inputs. In short, when the forces applied by the pilot or co-pilot to counter the trim reach 24–36lb, two micro switches disengage the autopilot and the stabiliser trim in the unscheduled direction.

All three actuators for the rudder and elevators are dual tandem types, with each of the two cylinders utilising power from one of the two hydraulic systems. Each actuator package consists of two shut-off valves, four filters, and two position transducers. They also employ two electro-hydraulic control valves that meter hydraulic fluid flow to an auxiliary servo actuator.

Lateral control and air braking are provided by a combined spoiler and airbrake system consisting of seven spoilers on the upper surface of each wing just aft of the rear spar. Rotation of the control wheel (attached to the control column) hydraulically actuates the spoilers on one wing, causing them to rise and interrupt the flow of air over the wing. This creates a reduction in lift and an increase in drag, which in turn creates a rolling movement. By contrast, when the airbrake lever is actuated the spoilers rise symmetrically to act as airbrakes. The spoilers, numbered from left to right 1 to 7 on the left wing and 8 to 14 on the right wing, each have a separate hydraulic actuator. The four outboard spoilers (1 and 2; 13 and 14) are mechanically linked to operate as a single unit and are termed 'group A'. The three inboard spoilers (5, 6 and 7; 8, 9 and 10) are also mechanically linked to operate as a single unit and are referred to as 'group



LEFT A combined spoiler/air braking system is employed to provide lateral control and air braking. Seven spoilers are located on the upper surface of each wing. (USAF)

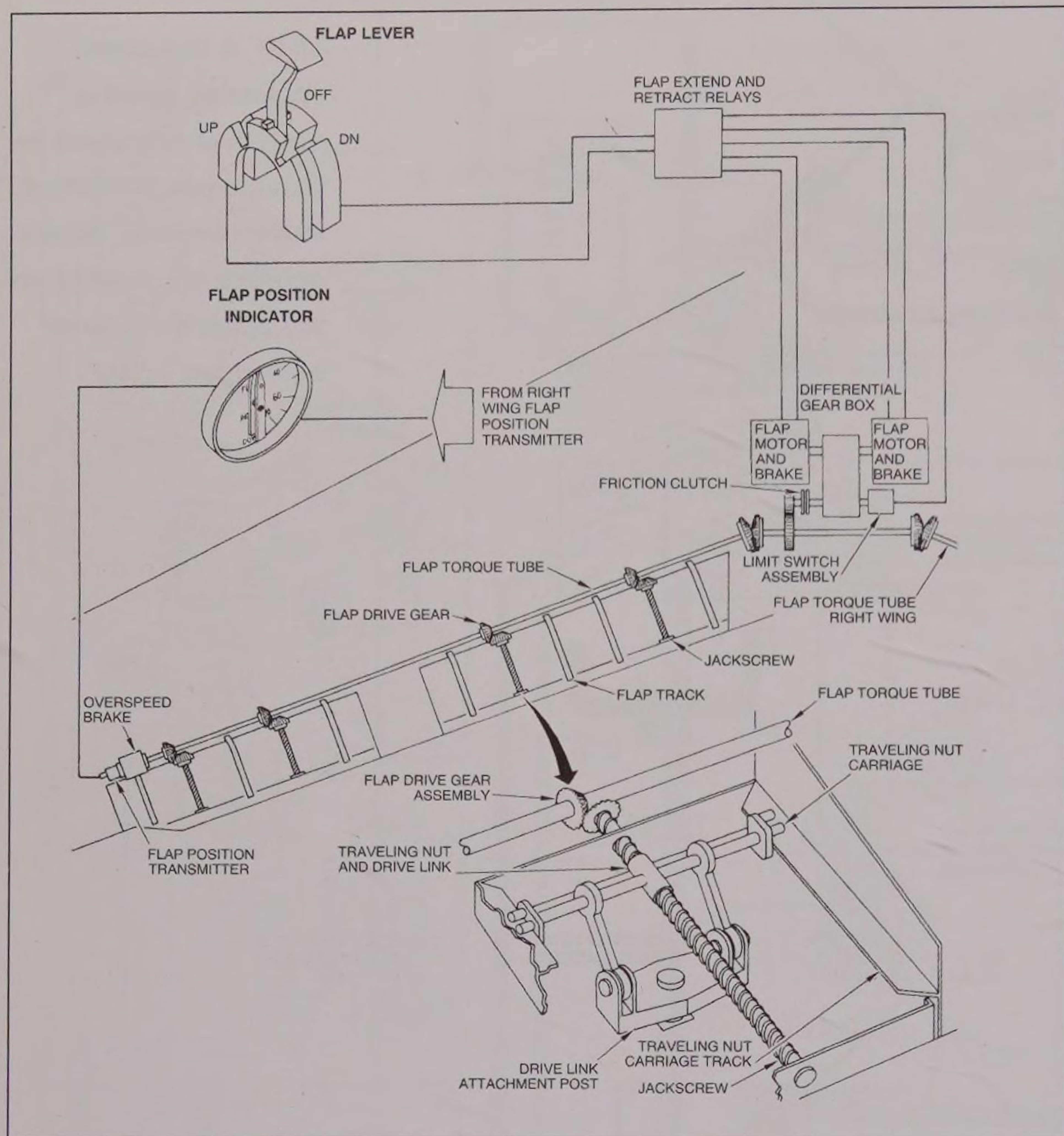
B'. Group A is powered by the outboard wing hydraulic system (hydraulic pumps on engines 1 and 7); group B is powered by the inboard wing hydraulic system (hydraulic pumps on engines 3 and 6).

Hydraulic pressure for the deployment of the spoilers is regulated by four metering valves, one for each group of spoilers per wing, but it is a mechanical system that automatically returns the metering valves to the closed position when the spoilers reach the position called for by the control wheels or autopilot. The spoilers are fully raised to 60° when the control wheels are at approximately 80° of rotation. At airspeeds above 250kt the spoiler actuators do not have sufficient force to raise the spoilers to their 60° position, although adequate roll control is still available under these conditions.

In order to provide additional space for the 'pilot not flying', each control column can be disconnected from the elevator system by pushing down on disconnect levers below the

outboard armrest and below the respective side panel of the pilot or co-pilot. This allows the column in question to be pushed forward into a recess in the front control panel. The control wheels each have a stabiliser and lateral trim button, an autopilot and air refuelling (IFR) boom release button, and an interphone-mike trigger switch on the outboard handgrip; and an EVS field of view select switch on the inboard grip.

Finally, the Stratofortress features a wing flap system consisting of four separate Fowler-type flap sections. These provide a high lift-to-drag ratio that shortens take-offs and reduces landing speeds. All four flap sections are simultaneously driven by a single power unit located in the fuselage, aft of the centre section gearspar. The power unit consists of two 205V three-phase AC motors joined by differential gearing, each of which has a brake that is electrically released only when the motor is energised and generating torque. A flap torque tube extends from each wing on the aft side of



movement. However, being 'Fowler flaps' they move rearward only for the remainder of the extension. The flaps extend on an exponential schedule, meaning that most of the drag increase occurs during the first 20% of the flap motion. Accordingly, for the first 20% of motion the flaps rotate down 29° in approximately 12 seconds. That leaves only 6° of remaining flap rotation for the remaining 80% of total flap extension.

The flaps are electronically controlled by a single flap lever, and there is no emergency extension or retraction control system. Some redundancy is built into the system, however, and should one of the two motors fail, the remaining motor will extend or retract the flaps in approximately 120 seconds. Control of the wing flaps is accomplished by moving a lever with an aerofoil-shaped knob on a detented quadrant located on the right side of the aisle stand. A dual wing flap position indicator reads from 0% to 100% of wing flap travel for each wing; the inclusion of a dual indicator system ensures that any difference in position of the left and right wing flap sections is highlighted to the pilot. If the flaps are not set for take-off, a warning horn signals for their extension when the aircraft is on the ground and the throttles for engines 3 and 5 or 4 and 6 are beyond approximately 45° of travel.

the gearspar and drives two jackscrews in each flap section to extend or retract the flaps.

During the first 37.5% of extension the flaps rotate downward 35° with little rearward

ABOVE AND RIGHT
A travelling nut and drive link move the B-52's large trailing edge flaps in accordance with the pilots' positioning of the flap lever on the aisle stand. The 'Fowler flap' design is readily apparent in this photograph of a B-52H belonging to the 93d Bomb Squadron, Barksdale AFB, Louisiana. (USAF)



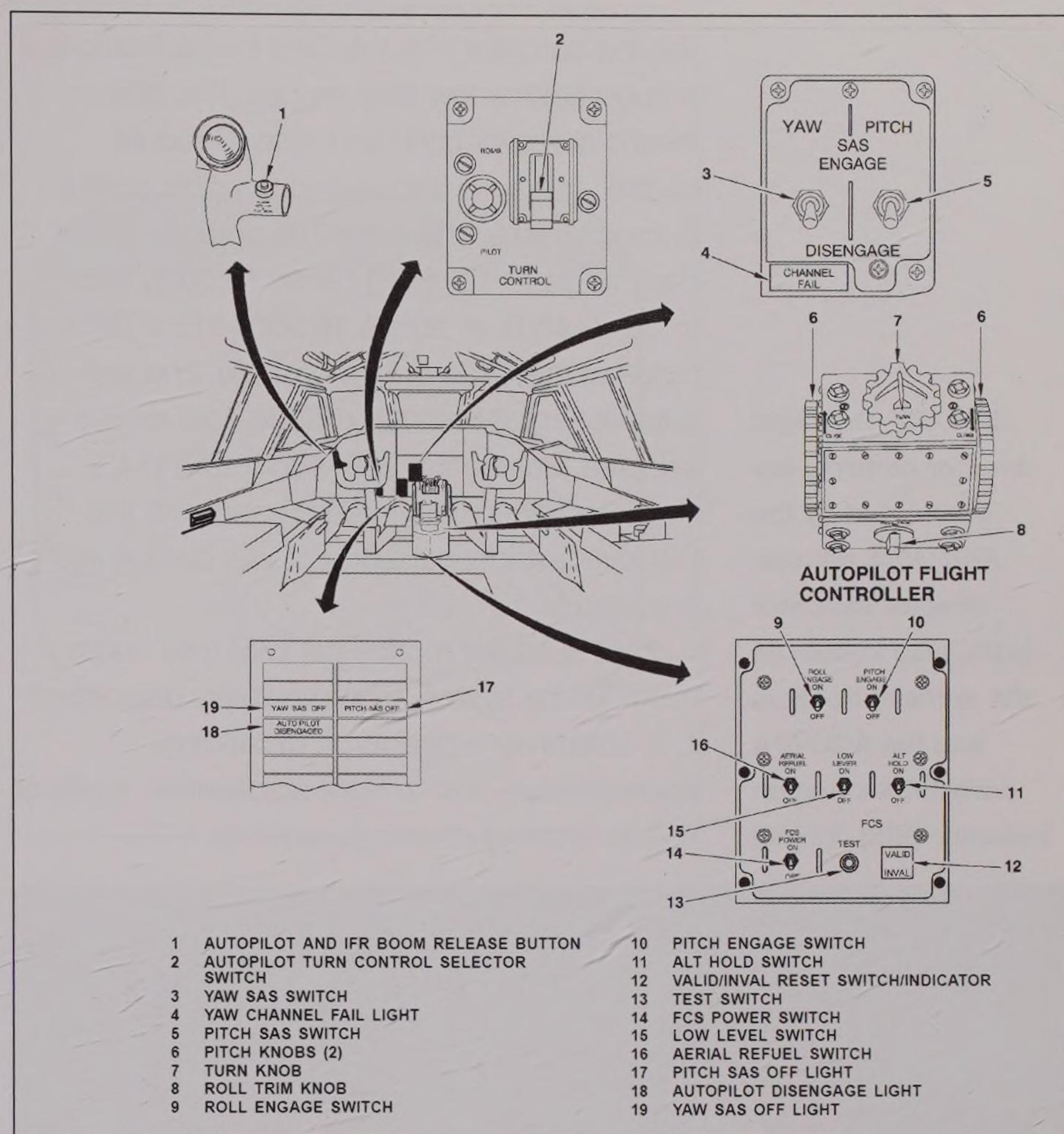
Automatic flight control system

The B-52's automatic flight control system (AFCS) is more often referred to as the autopilot, and provides automatic flight control in two main modes: 'non-steering' and 'pitch and roll steering'. An auxiliary facility, 'bomb mode', integrates the autopilot with the OAS. An interlock ensures that the pilot has primary flight control at all times. The autopilot is powered by 118V single-phase AC power.

The non-steering mode offers four options: 'stabilisation', 'altitude hold', 'pitch hold' and 'roll hold'. It is so called because the pilot can fly the aircraft 'hands free' any time the 'roll engage' and/or 'pitch engage' switches on the control panel are set to the 'on' position. The auxiliary 'stabilisation' function holds the aircraft in straight and level flight in order to maintain a constant heading, based on signals received from the AHRS. The altitude hold mode maintains the aircraft at a constant barometric pressure altitude (the altitude at which the aircraft was flying when this mode was selected), but this function is selectable only after the pitch hold mode has been engaged. With altitude hold engaged, pressure signals from the air data sensor unit are processed by the FCS processor to control elevator and stabiliser trim as required.

Conversely, the steering mode derives its name from the fact that pilot pitch and roll inputs are coupled with those of the autopilot. There are two main options: 'aerial refuel' and 'low level'. The former is intended to reduce the workload during aerial refuelling, while the latter reduces pilot fatigue during low-level operations. Whichever option is selected, the pilot flies the aircraft by control column inputs as normal, the difference from normal flight being a substantial reduction in control column forces. The pilot's inputs generate electrical signals through force transducers in the control columns, and these signals are sent to the autopilot to alter pitch and roll. This contrasts with the non-steering mode, where autopilot pitch, turn, and roll knobs (via the control column) are used to effect changes in attitude while the autopilot is engaged.

The maximum bank angle in aerial refuel mode is 40°, and 45° in low level mode, and



feedback to the pilot is given by a stiffening of lateral control force when angle limits are approached. The pilot will feel very little resistance in the lateral controls for bank angles up to 8°, and any bank angle commanded by the pilot between 8° and 45° will be held by the autopilot regardless of changes to power or airspeed. Increasing the bank angle beyond these limits results in autopilot disconnection.

One crucial difference between aerial refuel and low level modes exists. During aerial refuel mode the autopilot will maintain a constant attitude and will resist attempts to change that attitude. The autopilot will keep the aircraft at its original attitude unless the pilot holds a particular change to pitch or bank angle for a sufficient period of time to allow the autopilot to adjust. Once it does so, it will maintain the new attitude. Changes in pitch attitude will also be maintained by the autopilot in low level mode, regardless of changes in thrust or airspeed, but in this mode pitch changes through the control column are met by gradually increasing control forces.

Finally, by positioning the autopilot 'turn control' selector switch to 'bomb' the pilot can engage the auxiliary bomb mode. This

ABOVE Controls for the B-52's automatic flight control system are located at five locations in front of the pilot. In addition, FCS cautions are presented on the annunciator panel to the right of the pilot's right knee. (USAF)

ties the autopilot into the OAS in stabilisation, altitude hold or low level modes. The pilot retains autopilot pitch and manual rudder control, but autopilot roll and heading control is transferred to the OAS. The autopilot limits bank angle to $15^\circ (\pm 3^\circ)$ below 18,000ft and to $38^\circ (\pm 4^\circ)$ at or above 18,000ft in the NAV mode of the OAS. In bomb mode, and with autopilot stabilisation or altitude hold modes selected, bank angle is limited to $38^\circ (\pm 4^\circ)$. However, when this mode is used with the low level autopilot steering mode, bank angle is limited to $15^\circ (\pm 3^\circ)$.

BELOW The flight director controls are dominated by the ARU-49/A attitude director indicator (ADI), also known as the artificial horizon, and the AQU-2/A horizontal situation indicator (HSI). (USAF)

In all autopilot modes the pilot may 'force override' the system to immediately disconnect it. A column or wheel force exceeding approximately 30lb in flight stabilisation mode or 40lb in steering modes is required.

Flight director and terrain avoidance

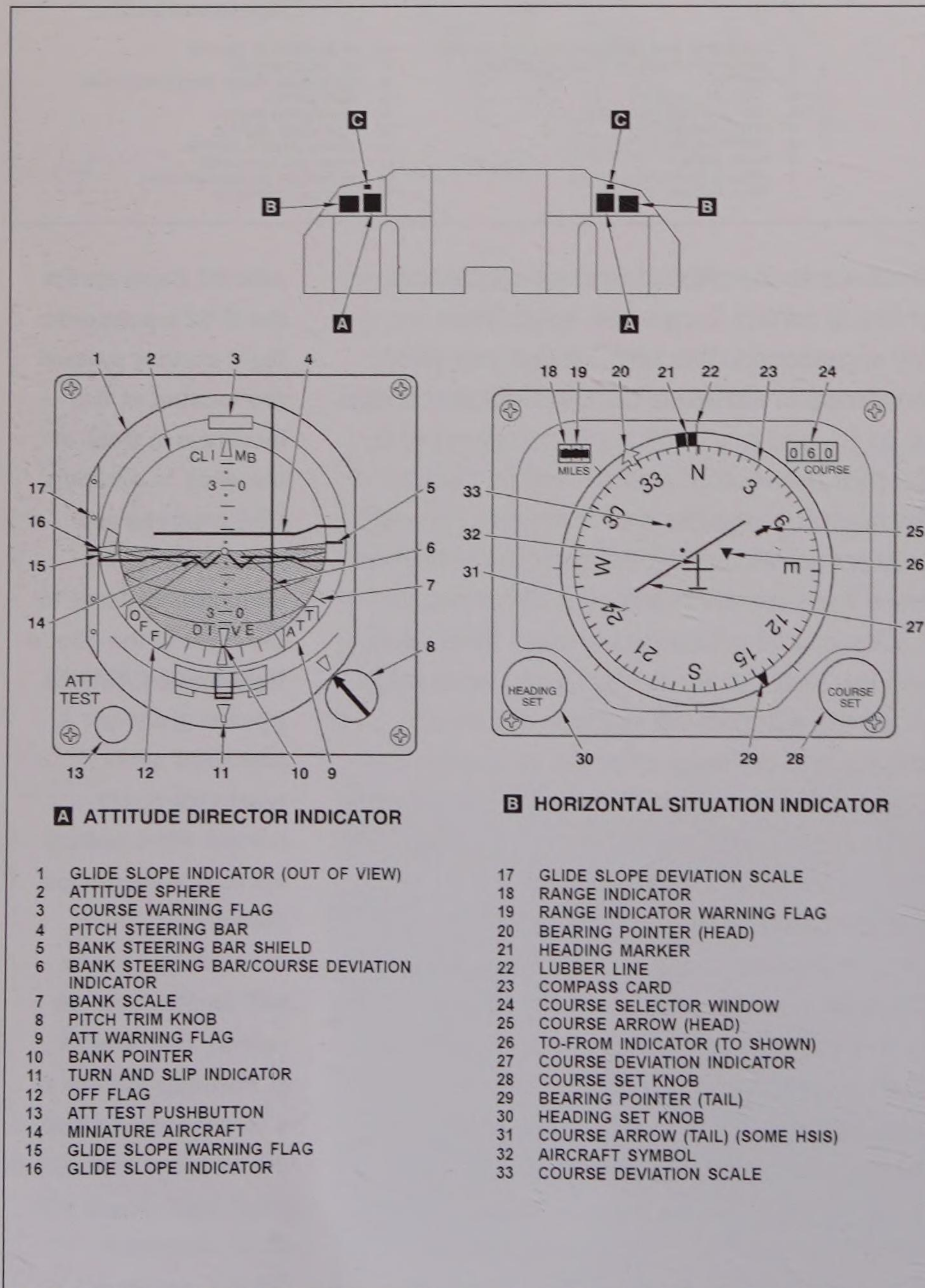
The flight director provides the pilot and co-pilot with information regarding the aircraft's attitude, heading and position. It also provides a visual display of attitude, altitude and heading steering commands in all phases of instrument flight.

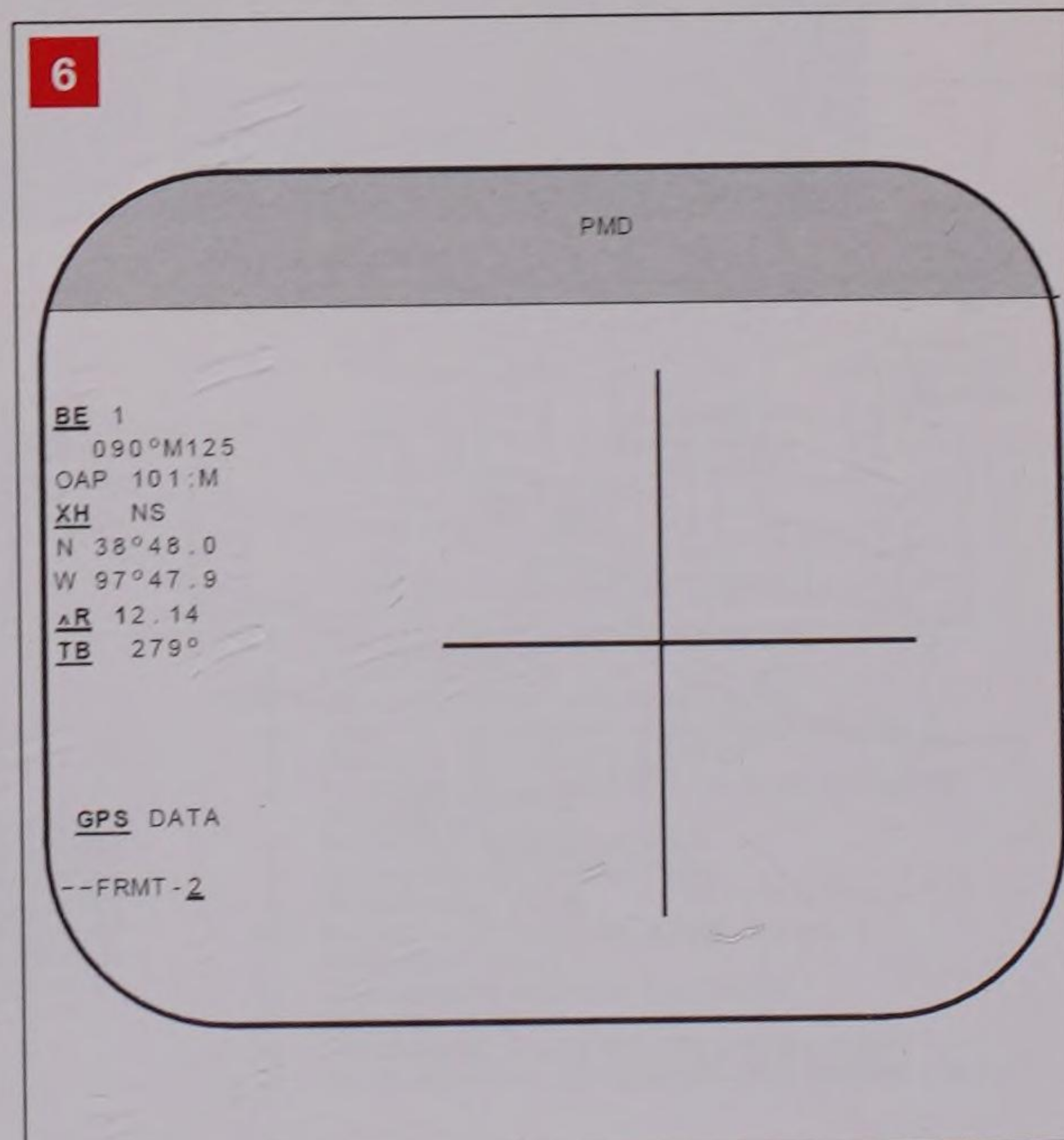
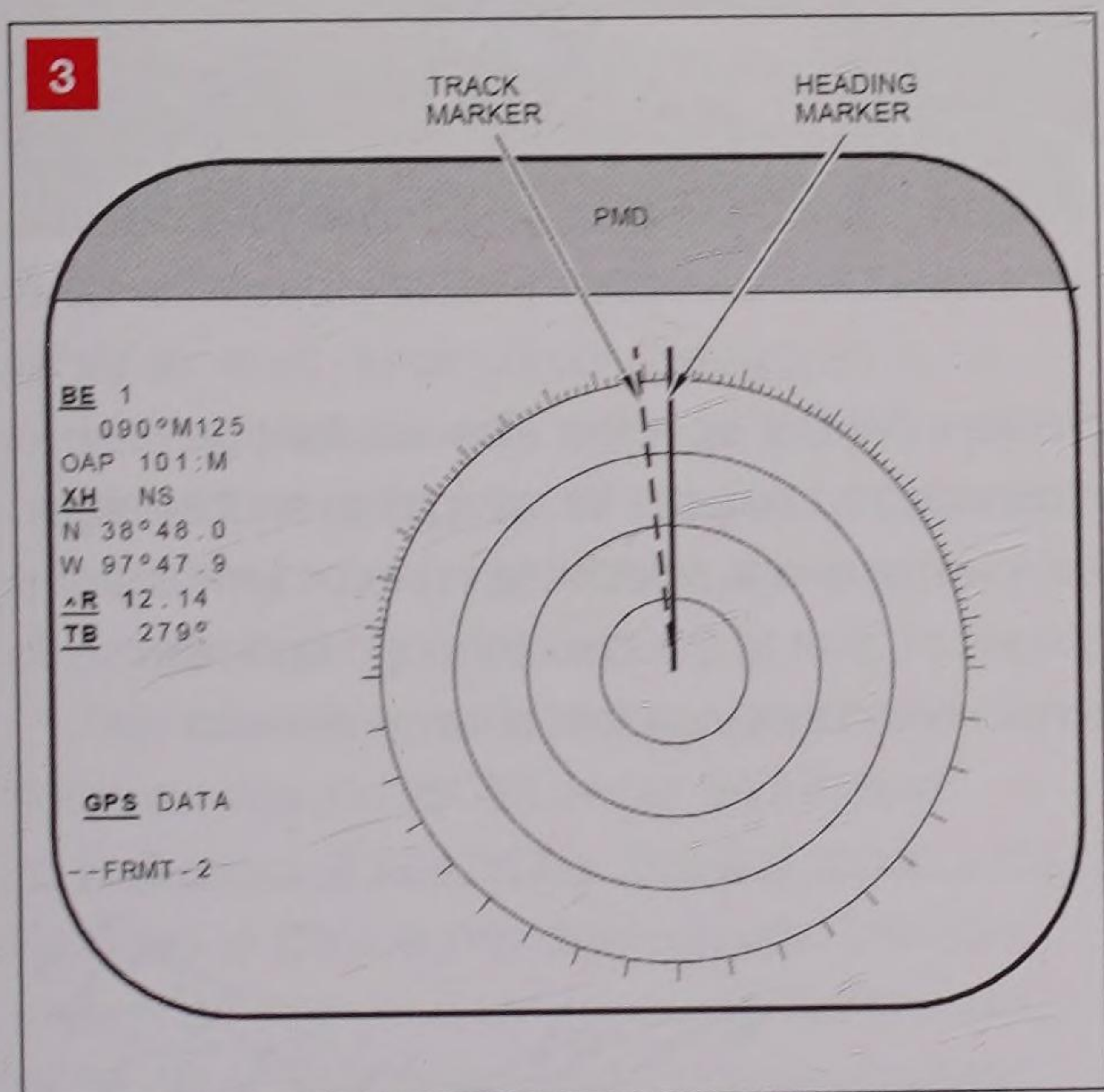
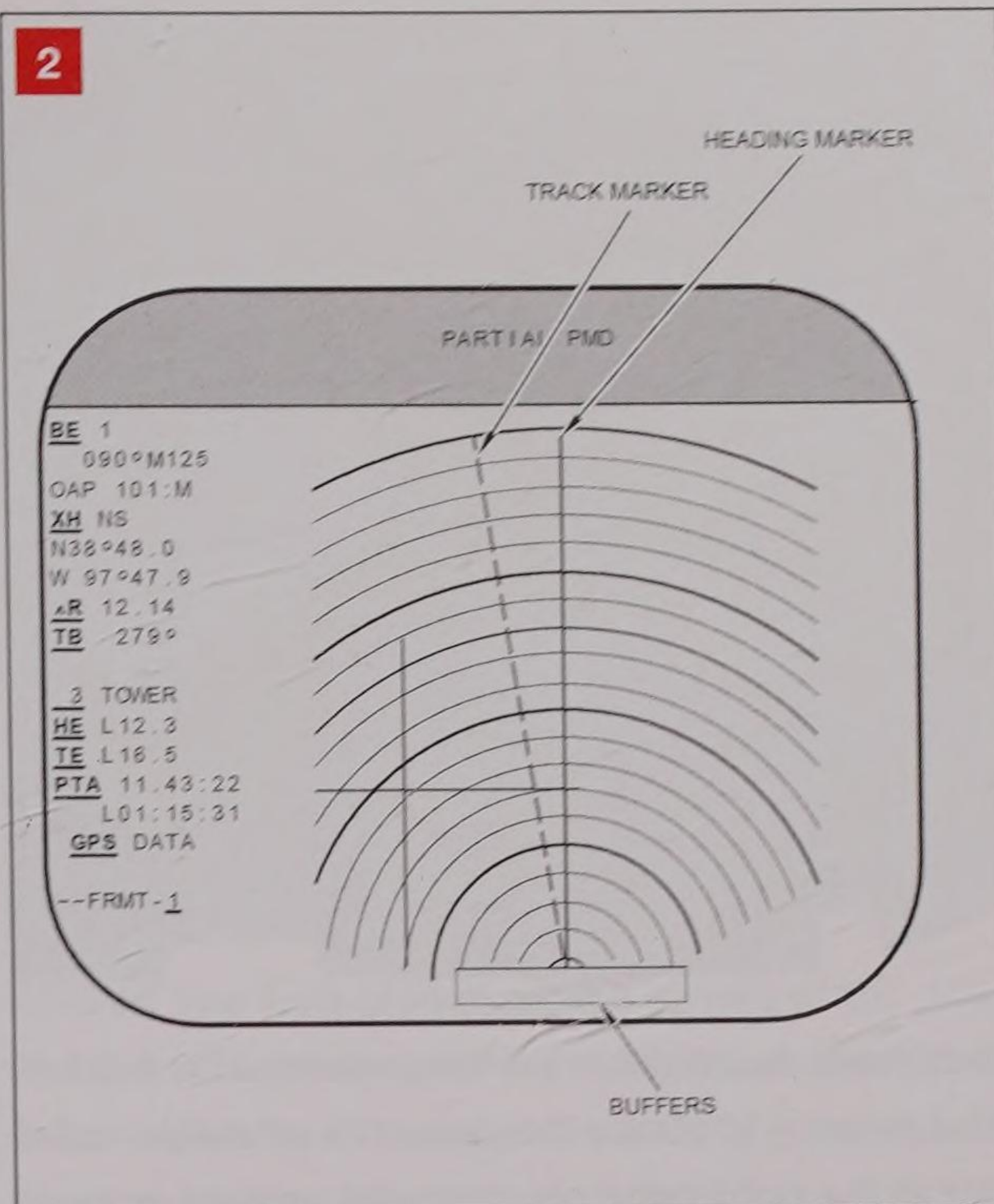
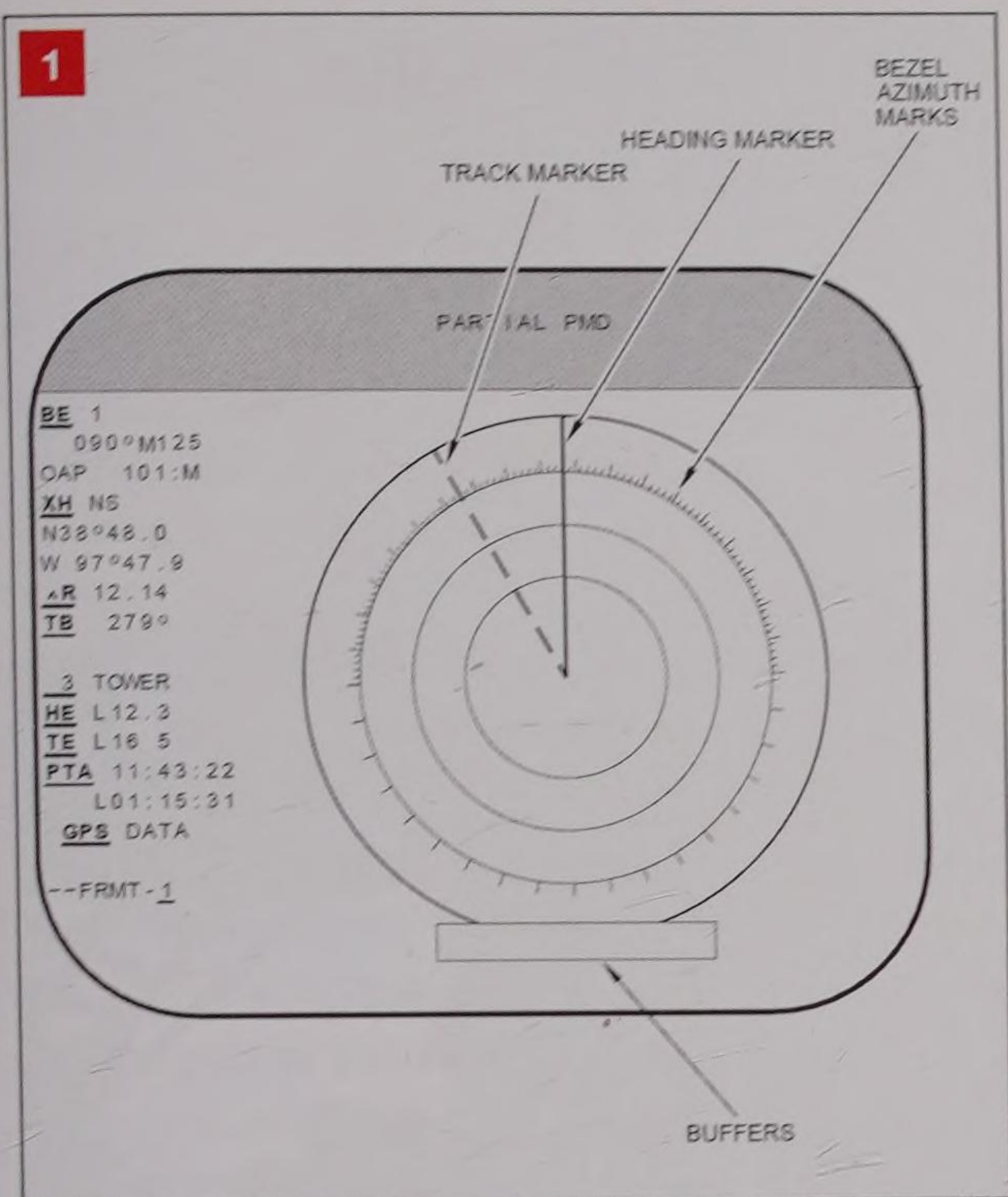
It comprises these main elements: ARU-49/A attitude director indicator (ADI), AQU-2/A horizontal situation indicator, nav system select panel switches, flight director controls, CPU-4A flight director computer, and turn rate gyro. The mode select switch on the nav system select panel chooses TACAN, VOR (VHF omnidirectional radio range), ILS (instrument landing system), ILS APP (ILS approach) or GPS for display. Inputs to the flight director system are provided by the TACAN, ILS/VOR, glide slope receiver and GPS systems. Pitch and roll is supplied by either the AHRS (co-pilot's ADI) or MD-1 gyro (pilot's ADI).

Meanwhile, terrain avoidance (TA) comes courtesy of the AN/APQ-166 strategic radar set group. This is made up of a receiver-transmitter/modulator (RTM), antenna system, radar processor, display generator and radar navigator management panel.

The TA system operates on the monopulse radar concept, providing range, azimuth and height data on each target from a single

OPPOSITE PAGE The APQ-166 strategic radar is used to provide the B-52 crew with attack and terrain avoidance capabilities. In this series of images and illustrations, the three main display modes are explained: (1) The plan position indicator (PPI) places the aircraft in the centre of the map [1-4], as shown in three of the four displays in this image of the lower crew compartment. (2) The displaced PPI (DPPI) display moves the centre of the radar sweep to the edge of the scope, as shown in [5]. (3) Spotlight mode focuses the radar beam on the point at which the crosshairs have been placed. Once the location beneath the crosshairs has been selected, the radar scope display changes to place the crosshairs at the centre [6]. (USAF)





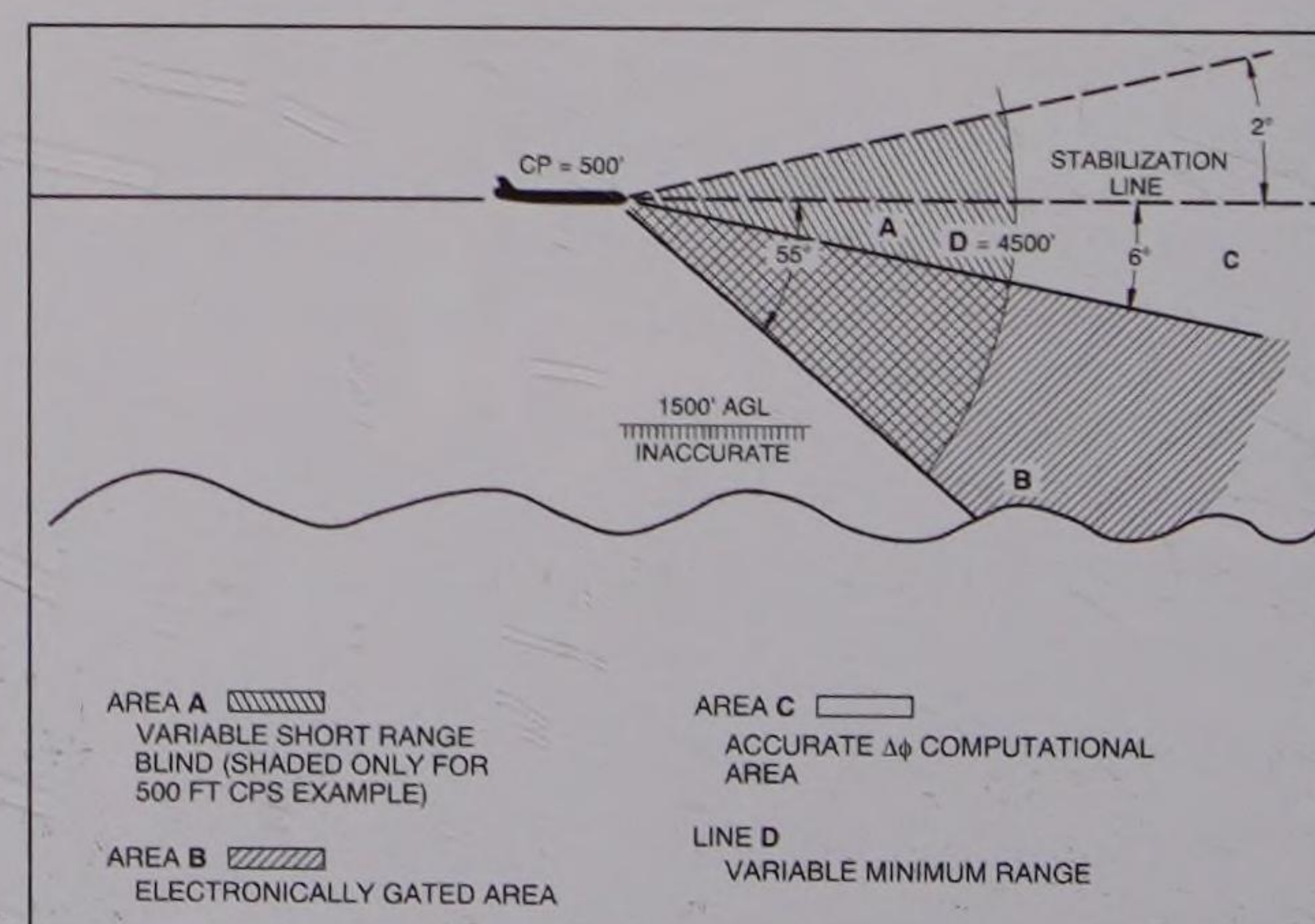
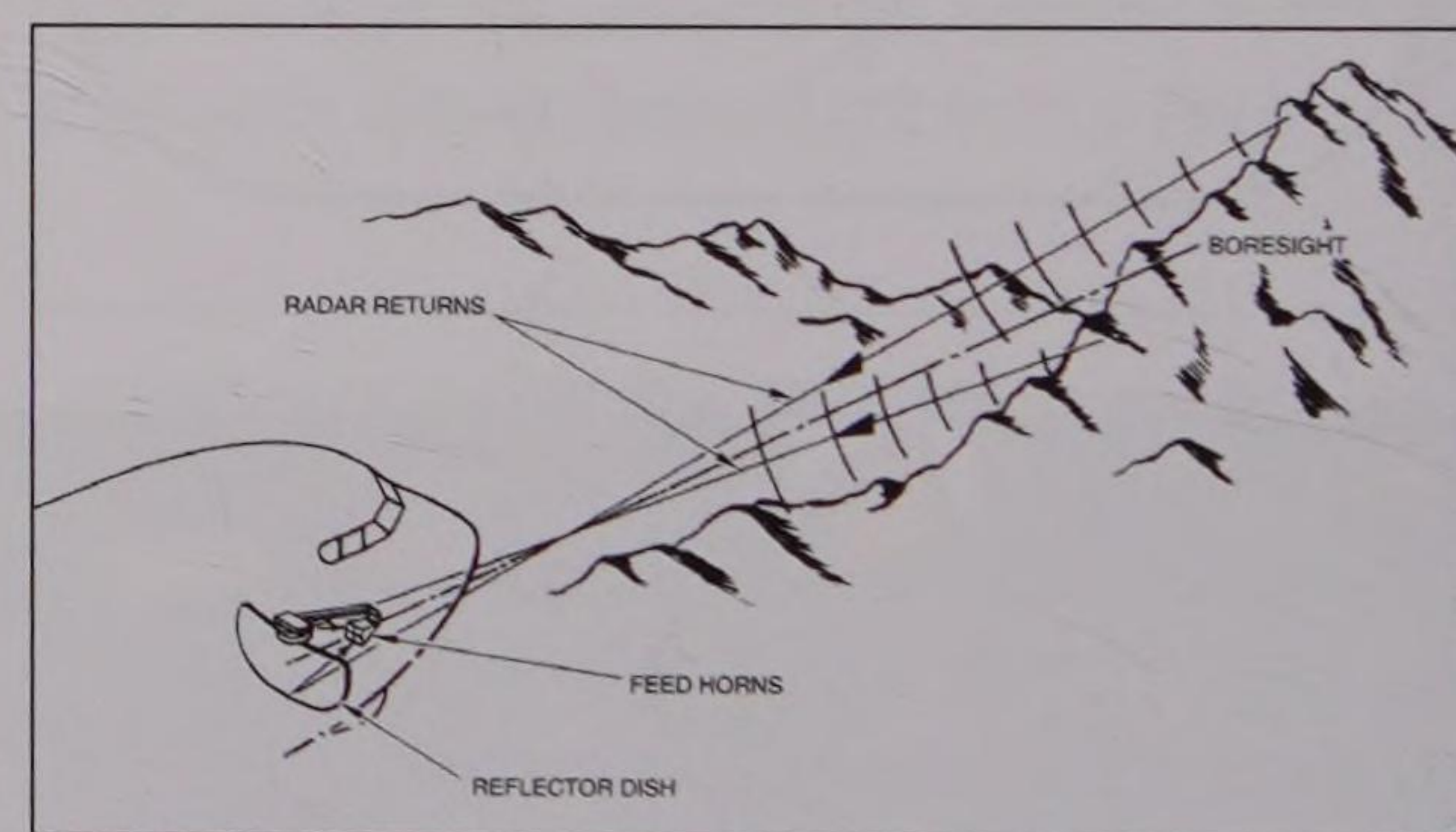
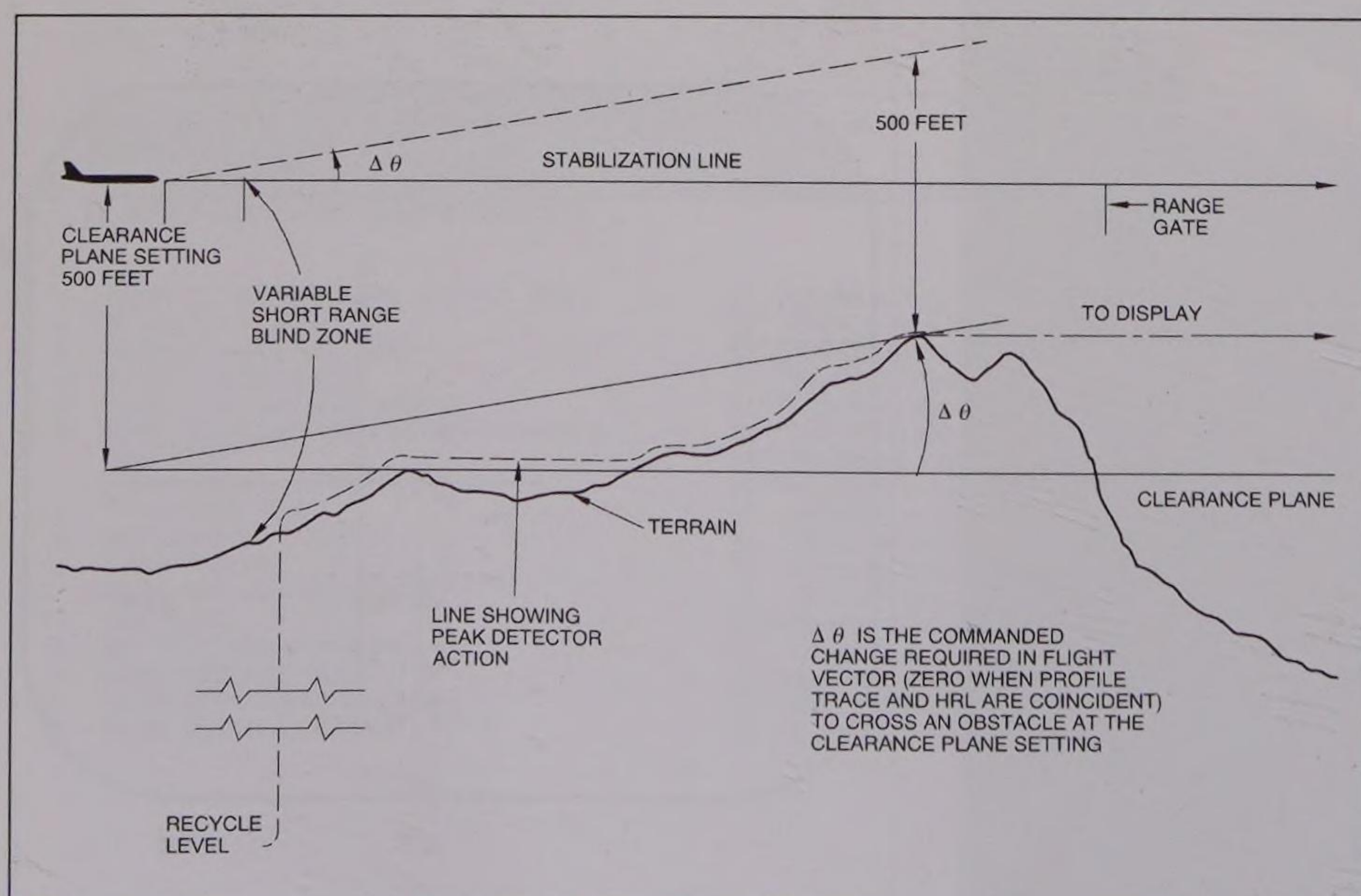


ABOVE AND RIGHT Two Phase maintainers lift the radome of a B-52 at Andersen's Hangar 1. The radome protects the aircraft's strategic radar (seen just behind the ladder in the right-hand photograph), and an array of antennae, horns and dipoles associated with the defensive systems suite. The bulbous 'horns' that protrude horizontally either side of the radome and are located above the EVS turrets house the ALQ-172 phased array 'transmit/receiver', also known as 'System 16'. (USAF)

transmitted pulse. In short, the radar set transmits high-energy RF pulses that bounce off terrain and objects (to include rain-bearing clouds when used as a weather radar), returning to the radar set for presentation on the navigator's multi-function

displays (MFDs) as video. The resultant ground map video is available for navigation and weather avoidance, and is selectable in increments from ranges of 3nm to 200nm, although optimum terrain avoidance requires a range selection of

RIGHT AND BELOW The APQ-166 operates in a variety of modes, allowing the pilots to select the most suitable mode for a given situation. These three illustrations offer an overview of the basic operating premise, in addition to the fundamental limitations, of the terrain avoidance radar mode. (USAF)



25nm or less. The set is powered by 115V AC and 28V DC.

There are two modes: terrain avoidance and navigation. In terrain avoidance mode (selected by the pilot) the radar processor analyses radar return signals to establish land masses below and forward of the aircraft, then displays the results as 'profile displays' on the pilot and co-pilot's EVS monitors. To compute this profile video the computer takes into account a number of variables, including antenna position, target range and vertical position. In navigation mode three display formats are possible. The first positions the aircraft in the centre of the radar map; the second places the aircraft on the edge of the radar map and shows a 180° field of view; and the third, a 'Spotlite' map, points the radar directly at the part of the map where the radar crosshair is positioned on the navigator's MFD, providing fast updates of a small swathe of terrain/airspace. Distances between the B-52 and an object of interest are calculated either as slant ranges (from the aircraft at its current altitude above a point on the ground) or ground ranges (range to the point of interest is calculated from a position on the ground directly beneath the aircraft).

There are three radar transmitter mode settings: beacon (BCN), radar (RDR), and radar/beacon (RDR/BCN). The first mode can be used to track a pre-defined radio beacon – such as that used by troops on the ground, or by other aircraft for rendezvous purposes – while the latter is a combination of normal radar and BCN tracking.

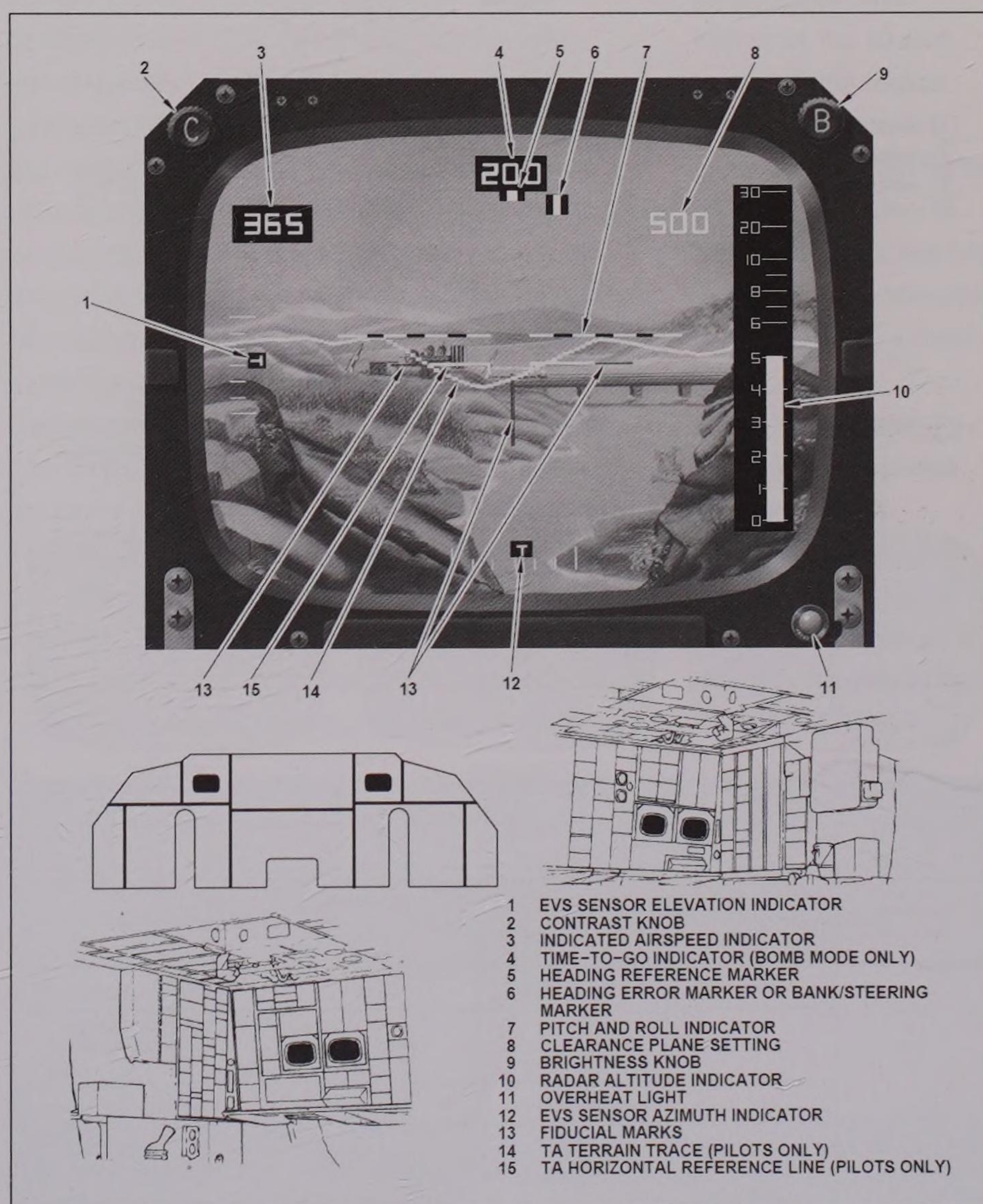
The AN/ASQ-151 electro-optical viewing system (EVS) is also a vital element in low-level penetration of enemy airspace and in terrain avoidance. It is composed of three major electronic and electrical subsystems: the AN/AVQ-37 steerable television set (STV), AN/AAQ-6 forward-looking infrared set (FLIR), and the OD-86/ASQ-151 data presentation group.

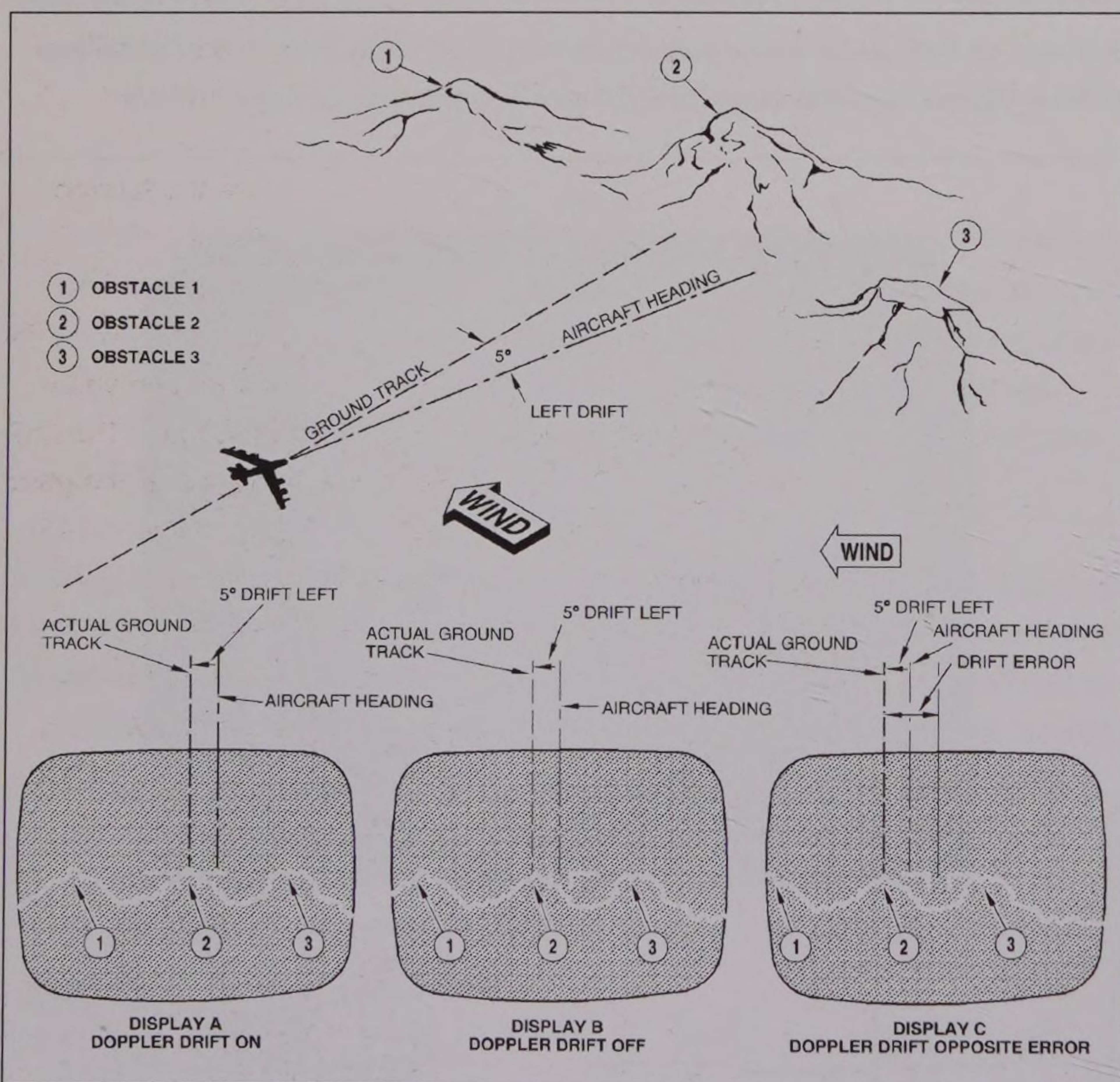
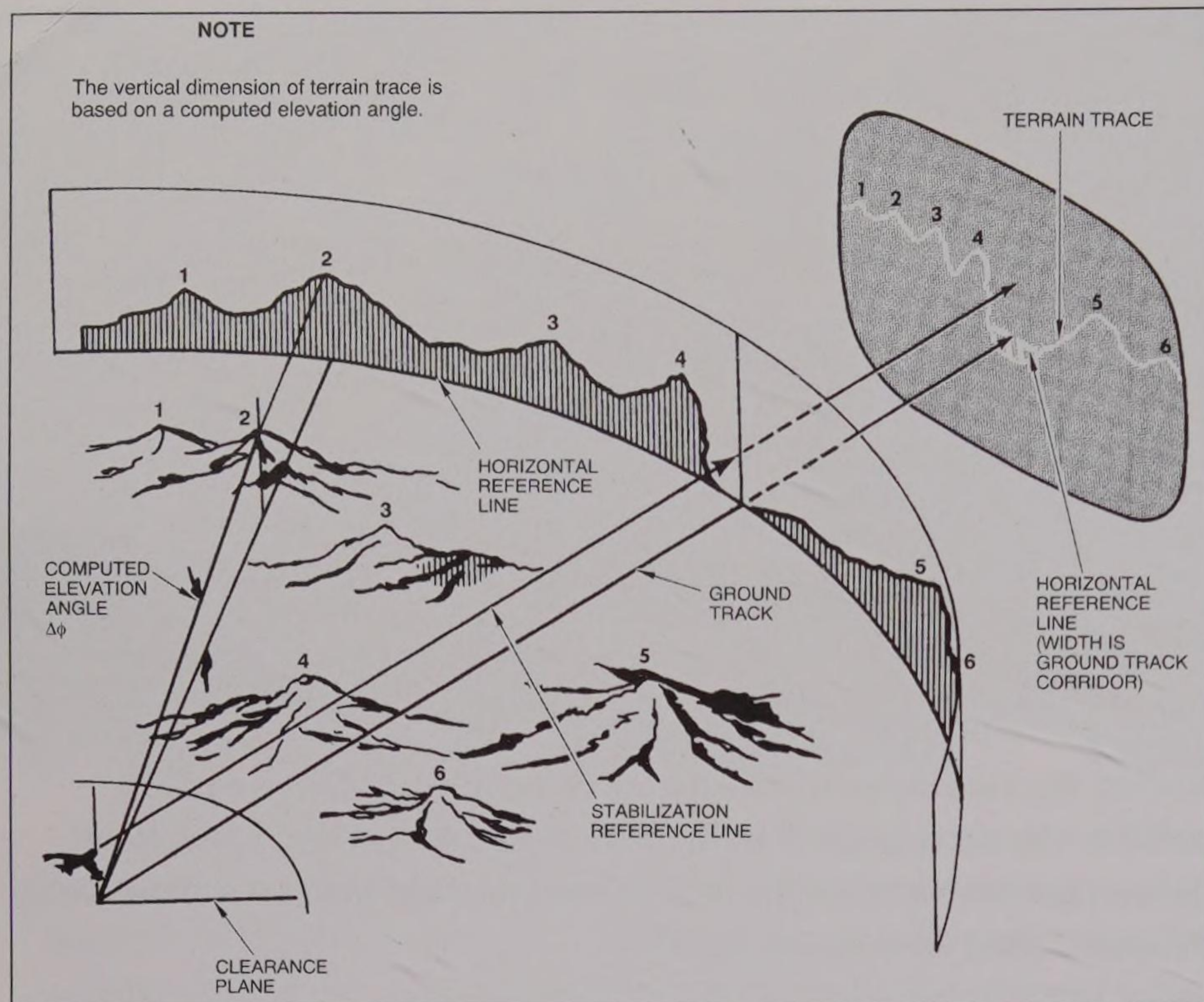
The EVS allows the crew to see ahead of the aircraft during both night and day ingress to the target. It employs the steerable AVQ-37 low light level television camera and AAQ-6 to display video on monitors at the pilots' MFDs in addition to those of the navigators. The OAS supplies TA profile



ABOVE The twin chin-mounted turrets of the ASQ-151 EVS are clearly visible in this photograph of a 5th Bomb Wing B-52H at Minot AFB, North Dakota. The turrets house the AVQ-37 steerable television set and the AAQ-6 forward-looking infrared set. (USAF)

BELOW The EVS system displays a range of data to the pilot and co-pilot (and can also be viewed by either navigator), and is primarily intended to allow low altitude ingress into the target area in any weather, day or night. (USAF)





MONITOR DISPLAY	SENSOR LOS	LOS COMMAND		
		VECTOR	FIXED	CRAB
STV or FLIR	Az	Flight Vector (Drift)	Centerline	Crab Angle (Aft Gear)
	EI	Flight Vector (Angle of Attack) + Roll Stabilization	2° Above Waterline + Roll Stabilization	2° Above Waterline + Roll Stabilization
STV or FLIR With TA	Az	Flight Vector (Drift)	Centerline	Crab Angle (Aft Gear)
	EI	Flight Vector (Angle of Attack) + Roll Stabilization	Waterline + Roll Stabilization	2° Above Waterline + Roll Stabilization

LEFT AND CENTRE The EVS displays the Terrain Avoidance video, on top of which is overlaid symbology showing actual ground track and aircraft heading, and a horizontal reference line. Careful use of the system is a must, since misinterpretation of the display, or a lack of understanding of the system's limitations, could be fatal. (USAF)

information that is overlaid on to the EVS video, giving the pilots all the information they require on a single display.

The STV and FLIR are both stabilised and are mounted within steerable turrets on the underside of the aircraft, just aft of the forward radome. The STV is on the left, the FLIR on the right. Both rotate in azimuth when in use, but are otherwise rotated to 180° into the stowed position when not in use. The STV can view selected areas within $\pm 45^\circ$ in azimuth of the aircraft centreline and can tilt $+15^\circ$ and -45° in elevation. The pilots can select from either a narrow or wide field of view (NFOV or WFOV) for both systems by simply toggling the FOV switch on the control wheel. The STV WFOV covers a viewing area $16.9^\circ (\pm 0.5^\circ)$ vertical and $22.5^\circ (\pm 0.5^\circ)$ horizontal; NFOV covers a viewing area $5.7^\circ (\pm 0.2^\circ)$ vertical and $7.6^\circ (\pm 0.2^\circ)$ horizontal. The FLIR viewing area is marginally smaller, $15^\circ (\pm 0.65^\circ)$ vertical by $20^\circ (\pm 0.6^\circ)$ horizontal for WFOV, and $5^\circ (\pm 0.2^\circ)$ vertical by $6.7^\circ (\pm 0.2^\circ)$ horizontal in NFOV.

A window-wash system provides a means of cleaning the FLIR and STV turret windows by means of high-pressure jets of warm water. A wash cycle is completed in 30 seconds and uses approximately 1.5 gallons of water. Approximately 14 gallons of demineralised water is stored in an electrically heated water tank, offering a total of nine wash cycles.

LEFT The EVS has three sensor stabilisation modes: vector, fixed and crab. In vector mode, the optics are cued to align with the aircraft's velocity vector (its path through the sky), while fixed mode stabilises the sensors to the aircraft centreline. Crab mode is used for landing, and aligns the optics with the crab angle dialled into the aft landing gear. (USAF)

Offensive systems

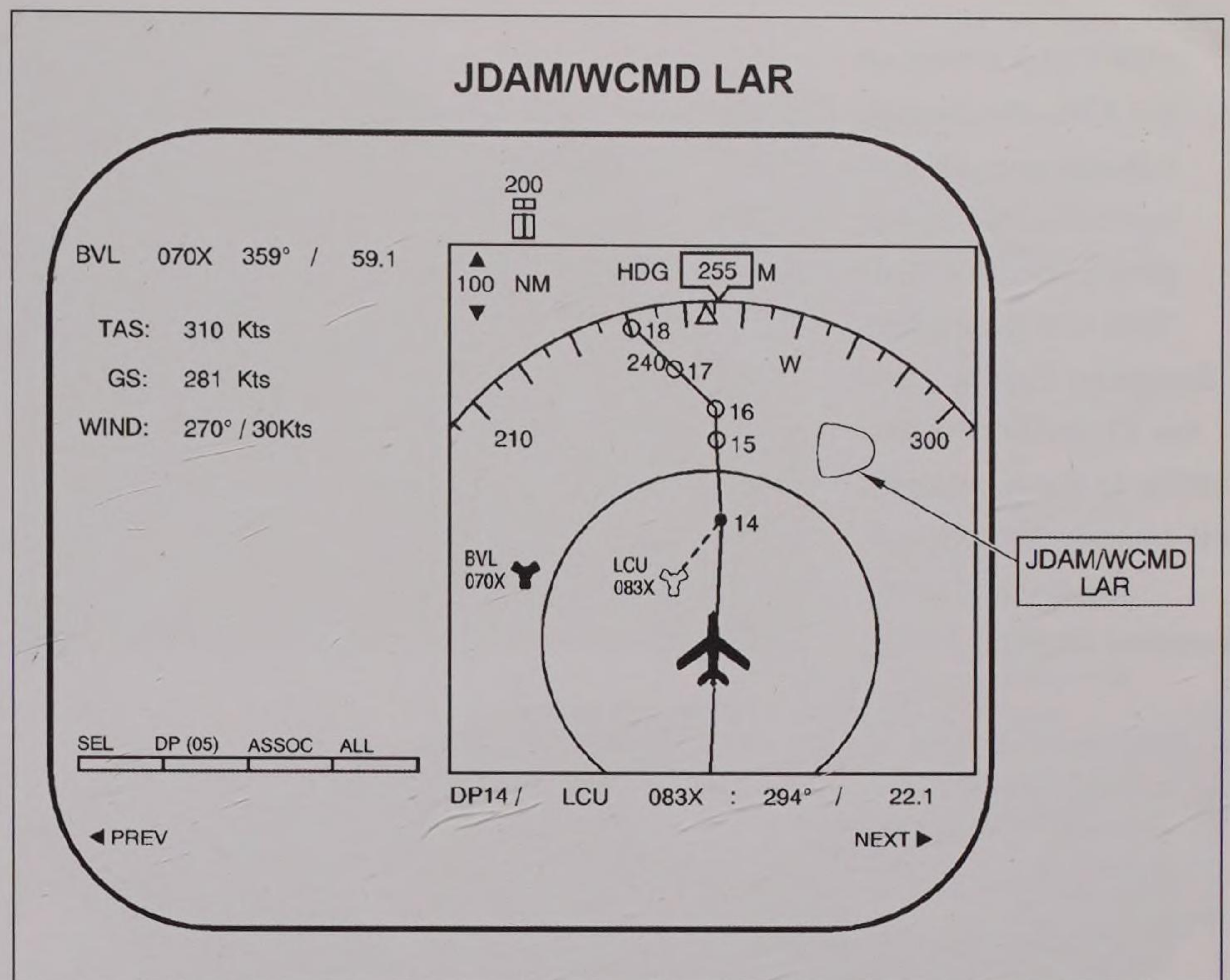
The B-52H Avionics Midlife Improvement programme upgraded the aircraft's OAS by introducing new avionics control units, the data transfer units and INS. The new AN/ASQ-176 OAS is now almost entirely automatic in weapons delivery and boasts the following hardware, some of which have already been discussed:

- Digital data set AN/AYK-17.
- Control-display set AN/ASQ-175.
- Ballistics computer set.
- Inertial navigation set.
- Electronic altimeter set AN/APN-224.
- Attitude heading gyroscope set AN/ASN-134.
- Radar navigation set AN/APN-218 (Doppler radar).
- Radar set group OY-73/ASQ-176.
- Control-monitor set AN/AWQ-3.
- Video recorder RO-523/ASQ-175.
- Global positioning system (GPS) AN/ARN-151(V).

As previously described, the OAS is also broken down by functionality into five subsystems, all of which interface the MIL-STD-1553 data bus. The focus of this section is to discuss the weapon control and delivery subsystem.

In automatic mode the OAS generates a release signal for weapons delivery, initialising, targeting, arming, monitoring and launching/releasing bombs and missiles automatically. To do so, it relies on the navigation subsystem to provide steering to the selected release or missile launch point, monitoring aircraft true airspeed, pitch and roll and altitude throughout. Given the varied weapons loads and mission tasking of the Stratofortress, the OAS is used for conventional and nuclear free-fall bomb delivery as well as conventional and nuclear missile delivery.

With conventional weapons, the OAS creates delivery solutions by determining the correct heading and release point for bomb release or missile launch. The processor uses programmed ballistics data, target altitude, aircraft altitude and ground velocities to determine steering commands. As it does so, it provides a 'time-to-go' value to the



release point. It also calculates the acceptable launch window for both powered and free-fall guided munitions such as the joint direct attack munition (JDAM) AGM-158 JASSM or AGM-86C/D CALCM. While the navigator can manually position his radar crosshair over a target in order to designate it, the OAS will also automatically compute a solution for programmed targets. Likewise, if the navigator wishes to fine-tune the target designation he simply uses his trackball to nudge the crosshair accordingly. If he wishes to exercise greater control over the entire sequence he may put the OAS into a 'bomb inhibit' mode that will give him final release authority, thus inhibiting the system from automatically releasing weapons. Nuclear weapons, such as the AGM-129 ACM and B-61 free-fall bomb, are employed in much the same fashion, although the OAS uses a separate 'nuclear logic' for additional security.

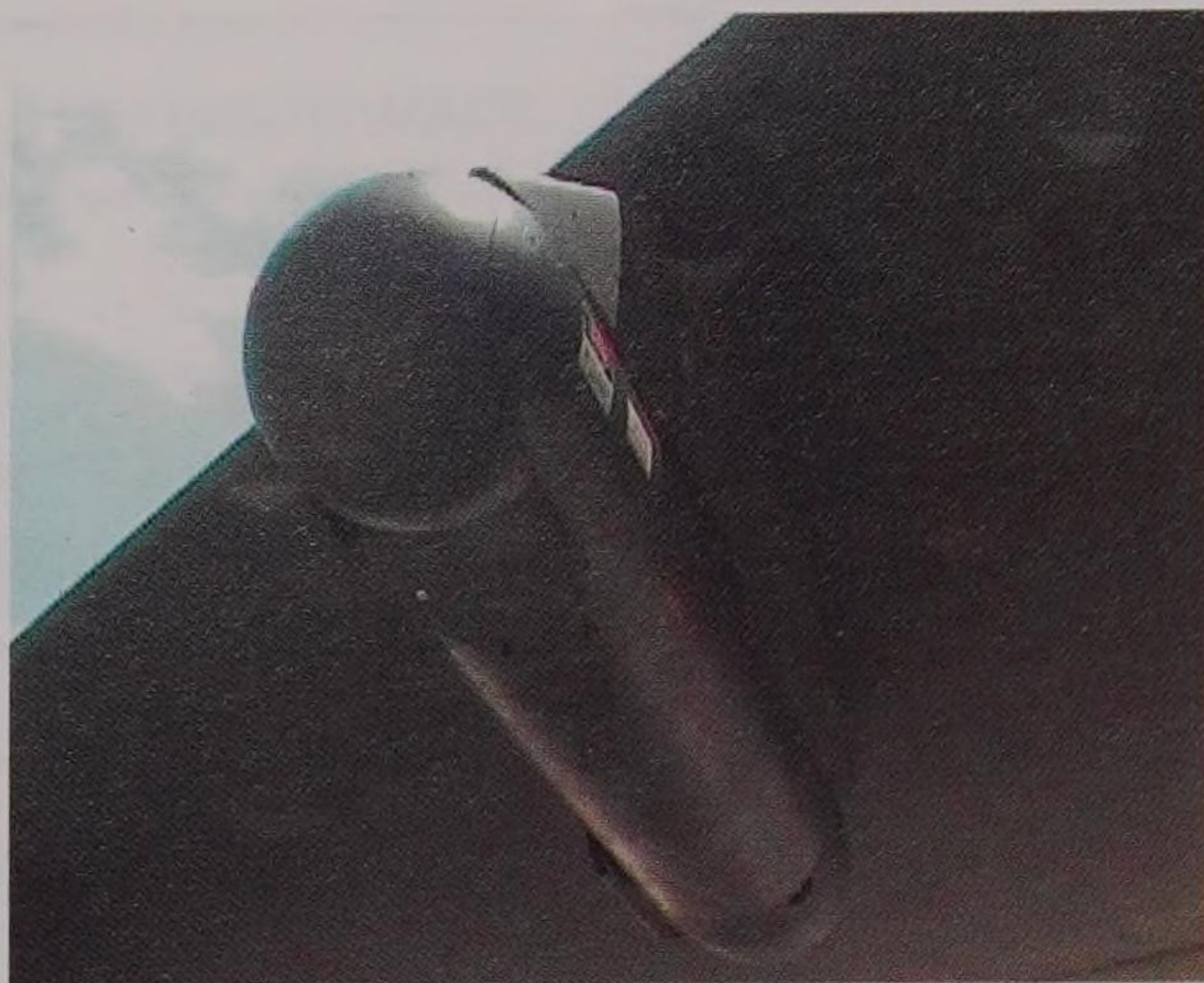
Recent combat operations in Afghanistan

ABOVE The OAS of the post-AMI B-52H is sophisticated enough to calculate such things as the launch acceptability region (LAR) of any 'smart weapons' carried by the aircraft. As shown in this illustration, the LAR is displayed to the pilots on their MFDs. (USAF)

BELOW An AGM-129 advanced cruise missile in flight. Faceted to reduce its radar cross-section, the ACM represents a stealthy version of the AGM-86. (USAF)



RIGHT The arrival of the AAQ-28 Litening II target pod, shown here attached to the wing pylon of a 49th Test and Evaluation Squadron B-52H, gave the Stratofortress the ability to autonomously find, identify and engage moving and time-sensitive targets. (USAF)



These systems, most of which are controlled from the EWO's station, fall within five main categories of equipment:

Receiver systems

An AN/ALR-20A search receiver provides the capability to simultaneously survey, detect and display all radio frequency transmissions in a given frequency band. The receiver generates audio signals that are transmitted through the interphone system, while a visual representation of these detected signals is presented on the EWO's IP-1168B video display. The receiving set is tied to ALT-32A and ALT-16A jamming transmitters (see below) to enable the EW officer to 'look through' the B-52's own jamming transmissions.

The B-52H is also equipped with an AN/ALR-46 radar warning receiver (RWR) – a small circular display that uses a CM-479 processor to alert the EWO when specific threat radar signals are received. It functions largely without operator input and converts raw radar signals into synthetic symbology for the EWO to see. It is typically programmed prior to take-off to alert the EWO about the presence of specific threats during the flight. AN/ALQ-172(V)2 PR transmitters 'blank' the warning receiver so that it does not display the aircraft's own transmissions. Like the ALR-20, the RWR generates audio cues and is also tied to the interphone system.

Finally, a sensor integration (SI) system complements the RWR and enhances the B-52's overall ability to display radar warnings. Located at the EWO station, it consists of a panel of ten lights and an 'SI display screen'. It works by pooling the raw threat warning data from the RWR, as well as threat warning and jamming information from the ALQ-172(V) and ALQ-155(V) ECM systems, and then analyses this information as a whole. In effect, it operates as a sophisticated RWR.

Blanking system

The blanking system prevents the B-52H's EW suite from displaying or reacting to the radio frequency signals coming from within the aircraft itself. 'Blanking pulses' that last fractions of a second serve to cut off the receiver systems described above during times when the transmitter systems (described below) are in

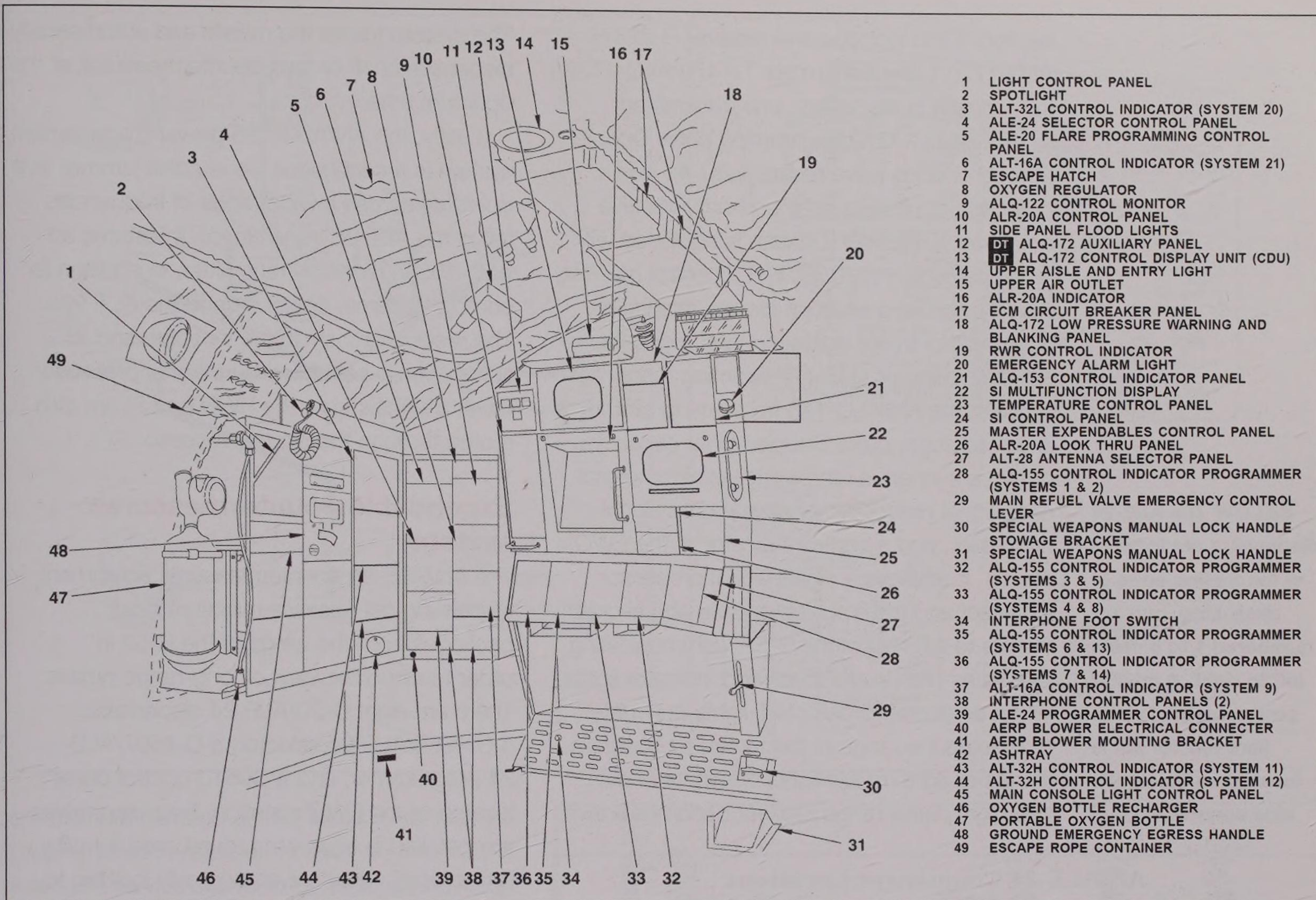


ABOVE Mounted on the CSRL, inert B-83 nuclear training rounds nestle snugly inside the B-52's bomb bay. (USAF)

and Iraq, where the close air support mission has been paramount, have also prompted installation of the AN/AAQ-28 Litening II and Sniper XR target pods. Equipped with stabilised IR and electro-optical sensors, these pods can also be used to dynamically target and track time-sensitive and moving targets. A modified Litening II, known as Litening ISR (intelligence, surveillance, reconnaissance) is equipped with a C-band transmitter to allow it to beam video from the pod to troops on the ground. Video from the pod is displayed on a dedicated video screen at the RN station (but may also be seen on any MFD) and is manually slewed by the RN via an integrated track handle.

Defensive systems

The B-52H is also equipped with an impressive array of defensive systems, making it more survivable in high threat environments and allowing it to operate in lower threat environments without dedicated SEAD (suppression of enemy air defences) escort.



- 1 LIGHT CONTROL PANEL
- 2 SPOTLIGHT
- 3 ALT-32L CONTROL INDICATOR (SYSTEM 20)
- 4 ALE-24 SELECTOR CONTROL PANEL
- 5 ALE-20 FLARE PROGRAMMING CONTROL PANEL
- 6 ALT-16A CONTROL INDICATOR (SYSTEM 21)
- 7 ESCAPE HATCH
- 8 OXYGEN REGULATOR
- 9 ALQ-122 CONTROL MONITOR
- 10 ALR-20A CONTROL PANEL
- 11 SIDE PANEL FLOOD LIGHTS
- 12 DT ALQ-172 AUXILIARY PANEL
- 13 DT ALQ-172 CONTROL DISPLAY UNIT (CDU)
- 14 UPPER AISLE AND ENTRY LIGHT
- 15 UPPER AIR OUTLET
- 16 ALR-20A INDICATOR
- 17 ECM CIRCUIT BREAKER PANEL
- 18 ALQ-172 LOW PRESSURE WARNING AND BLANKING PANEL
- 19 RWR CONTROL INDICATOR
- 20 EMERGENCY ALARM LIGHT
- 21 ALQ-153 CONTROL INDICATOR PANEL
- 22 SI MULTIFUNCTION DISPLAY
- 23 TEMPERATURE CONTROL PANEL
- 24 SI CONTROL PANEL
- 25 MASTER EXPENDABLES CONTROL PANEL
- 26 ALR-20A LOOK THRU PANEL
- 27 ALT-28 ANTENNA SELECTOR PANEL
- 28 ALQ-155 CONTROL INDICATOR PROGRAMMER (SYSTEMS 1 & 2)
- 29 MAIN REFUEL VALVE EMERGENCY CONTROL LEVER
- 30 SPECIAL WEAPONS MANUAL LOCK HANDLE STOWAGE BRACKET
- 31 SPECIAL WEAPONS MANUAL LOCK HANDLE
- 32 ALQ-155 CONTROL INDICATOR PROGRAMMER (SYSTEMS 3 & 5)
- 33 ALQ-155 CONTROL INDICATOR PROGRAMMER (SYSTEMS 4 & 8)
- 34 INTERPHONE FOOT SWITCH
- 35 ALQ-155 CONTROL INDICATOR PROGRAMMER (SYSTEMS 6 & 13)
- 36 ALQ-155 CONTROL INDICATOR PROGRAMMER (SYSTEMS 7 & 14)
- 37 ALT-16A CONTROL INDICATOR (SYSTEM 9)
- 38 INTERPHONE CONTROL PANELS (2)
- 39 ALE-24 PROGRAMMER CONTROL PANEL
- 40 AERP BLOWER ELECTRICAL CONNECTER
- 41 AERP BLOWER MOUNTING BRACKET
- 42 ASHTRAY
- 43 ALT-32H CONTROL INDICATOR (SYSTEM 11)
- 44 ALT-32H CONTROL INDICATOR (SYSTEM 12)
- 45 MAIN CONSOLE LIGHT CONTROL PANEL
- 46 OXYGEN BOTTLE RECHARGER
- 47 PORTABLE OXYGEN BOTTLE
- 48 GROUND EMERGENCY EGRESS HANDLE
- 49 ESCAPE ROPE CONTAINER

operation. Thus they help prevent the defensive suite from reacting to its own transmissions.

Transmitter systems

The AN/ALT-28(V) jammer or 'jamming transmitter' radiates RF signals over a wide frequency range through the use of interchangeable transmitter groups. Each of these groups covers a particular frequency band, allowing the ALT-28 to be individually configured to jam the most important threats likely to face the crew on a given mission. Each system consists of a transmitter and dual electronic equipment liquid cooler, antenna system, and shared access to the C-10130/ALQ-155(V) control indicator/programmer located at the EWO's station and described below. The control programmer allows the EWO to initiate a 'noise jamming' programme, creating a barrage of focused radio energy that overpowers and desensitises the threat system's receiver. This type of jammer is most effective at long ranges.

The AN/ALT-32A jammer functions in a

similar manner to the ALT-28, but includes both low-band and high-band sets simultaneously. The low-band set features a T-1086A/ALT-32A radio transmitter, T-1087/ALT-32A radio transmitter, PP-1087/ALT-32 power supply and the EWO's C-7721/ALT-32A control indicator. The high-band set features a T-1087/ALT-32A radio transmitter, PP-1087/ALT-32 power supply and a C-7722/ALT-32A control indicator.

Receiver transmitter systems

The AN/ALQ-172 countermeasures set combines with two AN/ALT-16A jamming 'power amplifiers' and an AN/ALQ-122 receiver-processor to form the ALQ-122/ALT-16A. This is a fully automatic receiving and transmitting jammer that offers protection against threat radars through 'deception jamming' – false radar returns that have different range and azimuth properties to the B-52.

The AN/ALQ-172(V)2 consists of two systems, designated 'System 15' and 'System 16'. System 16 is installed in the forward radome, while System 15 is installed in the tail

ABOVE The electronic warfare officer sits facing aft in the upper crew compartment. Photographs of the EWO station are prohibited, but this illustration provides a typical representation of the current unclassified configuration. (USAF)

section. Each includes one receiver R-2247/ALQ-172(V), one transmitter T-1470/ALQ-172(V) for jamming pulse radars, one transmitter T-1476/ALQ-172(V) for jamming pulse Doppler and continuous wave radars (LRU-4), and a collection of phased array and omni-receive antennae. The EWO's station is equipped with a dedicated C-11270/ALQ-172 control monitor, which provides a situation display offering a 360° view of threat emissions and a graphic representation of ALQ-172 jamming responses.

Next, the AN/ALQ-153 tail warning system is a solid state, pulse Doppler radar consisting of two antennae, a receiver-transmitter, digital data signal processor, analogue data signal processor, and a control indicator at the EWO's station. It employs a digital signal processor to detect and warn against missile and aircraft threats to the rear of the B-52, communicating threats as both audio tones and indicator lights. When an aircraft is detected, lights illuminate to indicate the range of the threat; for a missile, the left or right missile lights illuminate and a two-digit, digital range readout becomes active.

The system tracks the missile and automatically dispenses chaff or flare countermeasures at the optimum time.

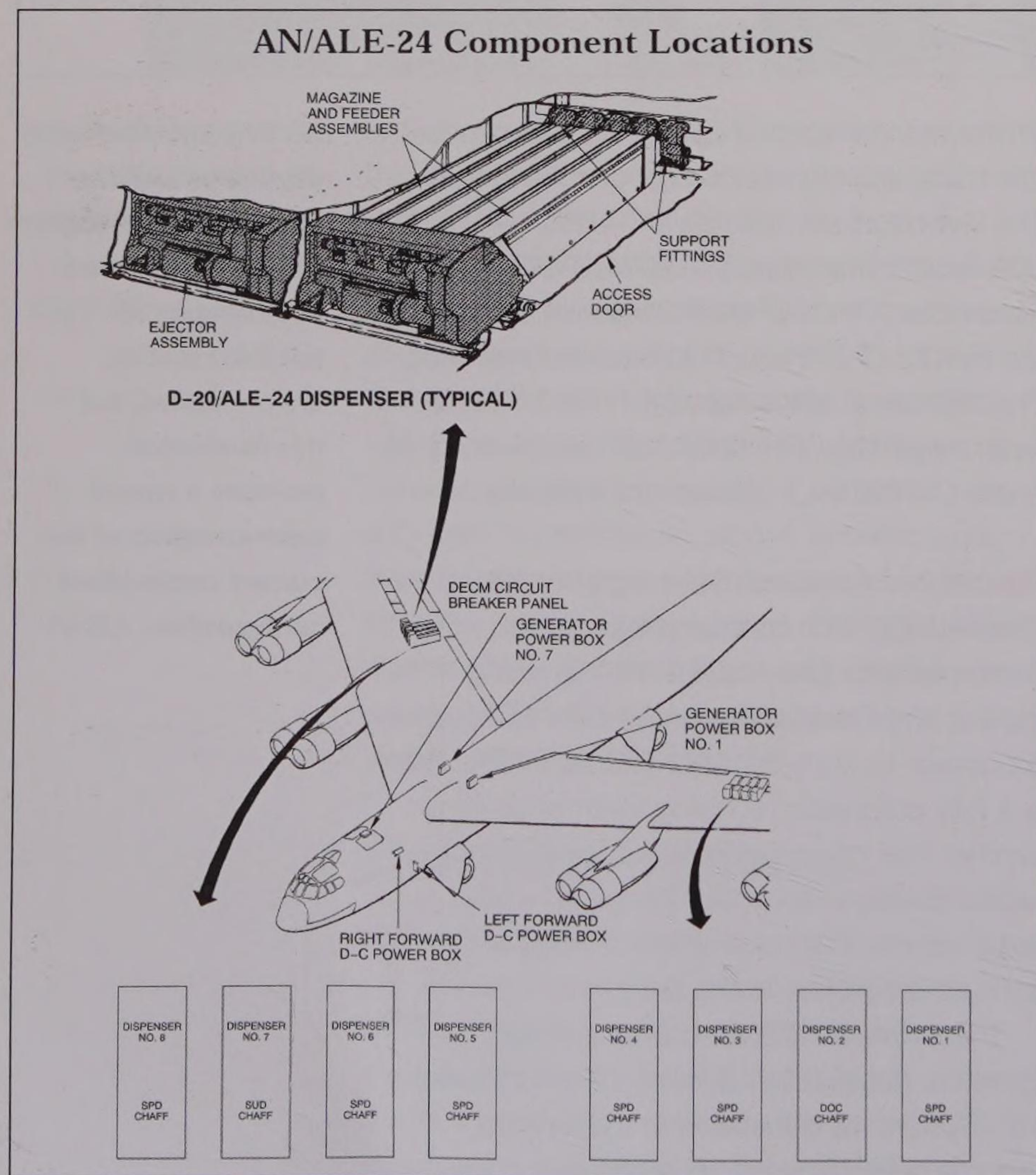
Lastly, the AN/ALQ-155 power management system is a continuous wave noise jammer that operates across a wide range of frequencies using the ALT-28 transmitters. It features an ALQ-155(V) receiver-transmitter, in addition to cooling systems, antennae and the ALT-28s. The receiver-transmitter is tuneable and is automatically controlled by a signal processor. Control signals from the RWR and SI are also routed through the signal processor.

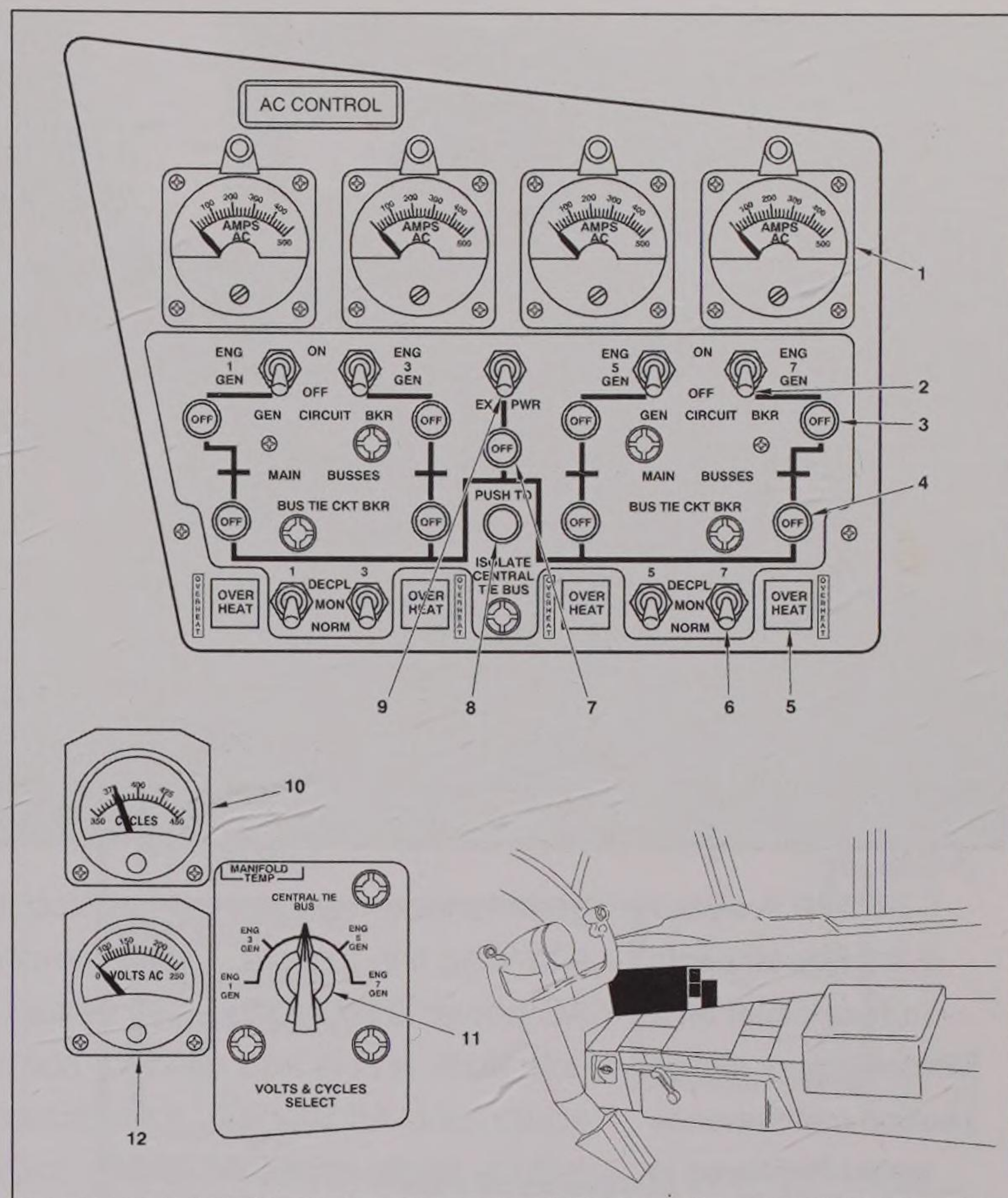
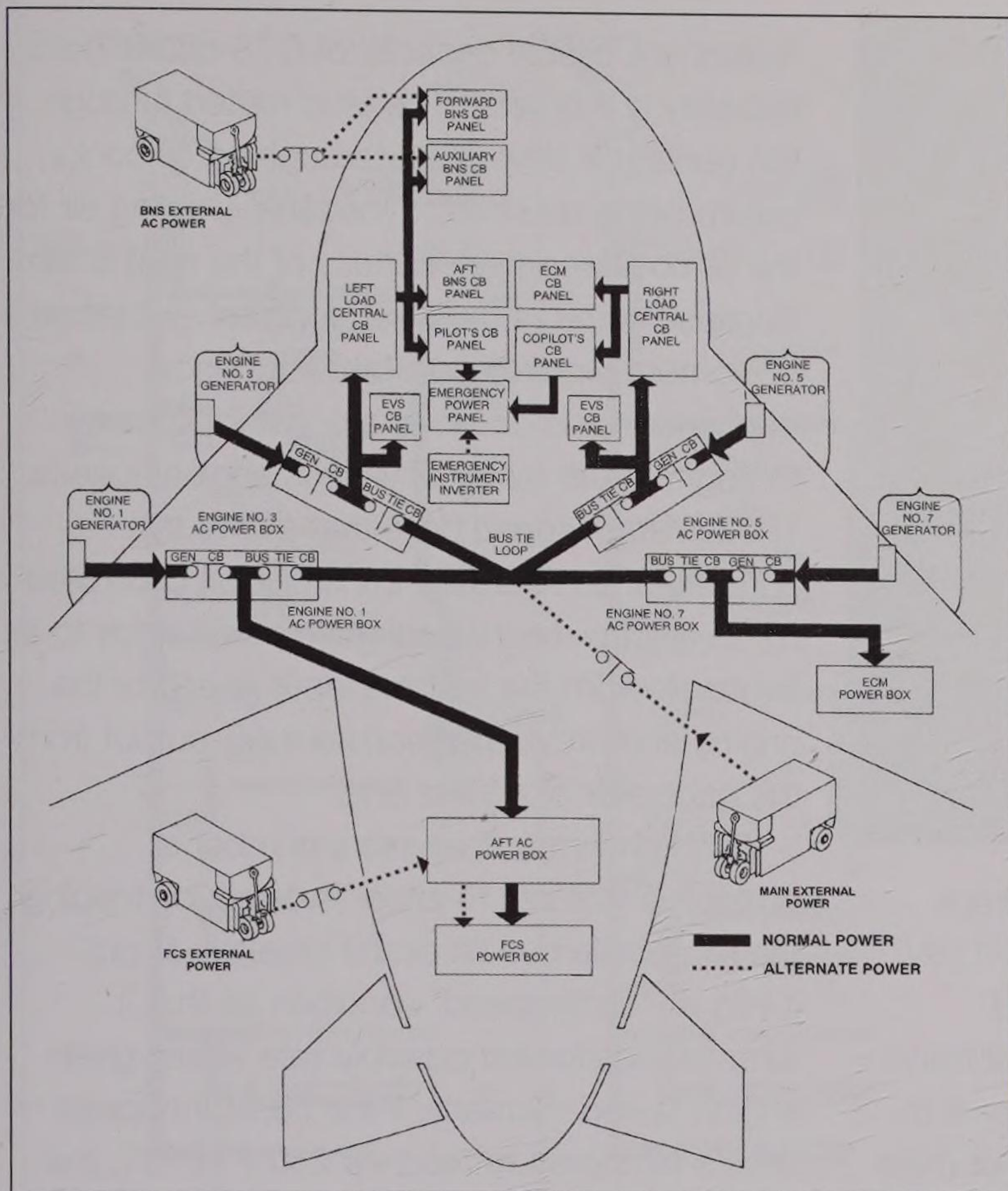
Expendable countermeasures systems

The AN/ALE-24 countermeasures equipment dispensing set releases miniature chaff packages from the wings of the B-52 in order to cloud the view of long-range radars. There are eight D-20/ALE-24 dispensers, a C-4508/ALE-24 selector, a C-4507/ALE-24 programmer, and a C9510 control panel located at the EWO's station. Four dispensers are installed in each wing, numbered 1 to 8 (left to right). They are strategically located to exploit the large volume of airflow turbulence behind the wing, thereby helping to make the chaff 'bloom' as it enters the slipstream. Similarly, the large lateral separation of the dispensers, and the simultaneous ejection of chaff packages from both wings in bursts of two, four, or six packages, makes for a more effective chaff cloud with which to spoof threat missiles or confuse threat radars. The set can accommodate 900 packages of self-protection dispensing chaff, 150 units of single unit dispensing chaff, and 75 units of delayed opening chaff. The EWO selects from one of a range of dispensing programmes, each with pre-set quantities and intervals for the chaff bundles. The ALQ-153(V) can also dispense chaff to counter aircraft and missiles approaching from the rear.

The AN/ALE-20 flare ejector system is used to deceive infrared guidance systems and missiles. It consists of a flare programming control panel at the EWO's station, one junction box, and a 'stepping switch' in each flare ejector case. The system employs 12 AN/ALA-17 flare sets with 16 flares per set, giving

BELOW The ALE-24 dispensers are located in the trailing edge of each wing, and are numbered 1 to 8, from left to right. A master power switch for the flare ejector set is located on the pilot's side console. (USAF)





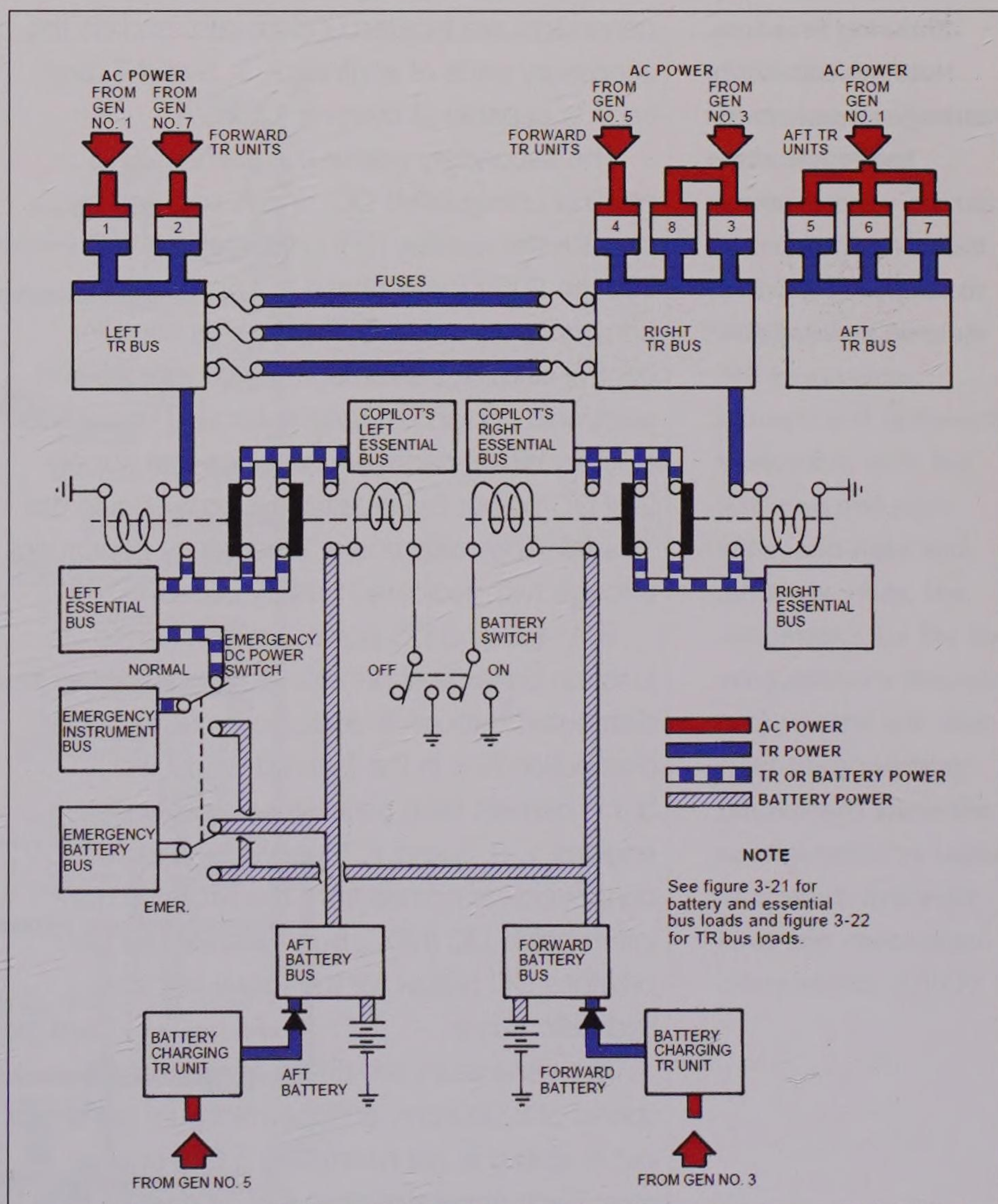
a maximum carriage of 192 flares. They may be programmed to release in bursts of one, two, or three at intervals of two to 20 seconds between bursts. They may also be released in a 'string' at a rate of one flare every 65 milliseconds, meaning that all 192 can be released in less than 20 seconds if required. The EWO uses the C9510 control panel to manually operate the system, but the ALQ-153 may also fire flares when the system is set to auto. The pilot's side panel features a power safety switch that inhibits flare release until it is put into the 'on' position.

Electrical system

The quantity and complexity of the electrically powered devices on the B-52H demands a robust and powerful electrical system. This is divided into a primary and a secondary distribution bus.

The primary bus is supplied with 205/118V three-phase AC power by four engine-driven

ABOVE AND RIGHT The AC electrical system in schematic form, along with associated cockpit controls. Generators on engines 1, 3, 5 and 7 provide normal power to the system. (USAF)





ABOVE A senior airman inspects a fuse panel on a Stratofortress during routine maintenance whilst deployed in support of Operation Enduring Freedom. Note the parachute storage compartment to the left of the airman – the crew don their parachutes prior to strapping into their ejection seats. (USAF)

generators to operate the fuel boost pumps and wing flap motors. The single-phase 118V AC power is routed to small motors and actuators, and is also used for some electronic equipment. Additionally, transformers serve to reduce single-phase AC power to 28V for most of the aircraft's lighting. The four engine-driven generators are located underneath, and on the accessory pads of engines 1, 3, 5 and 7, and each is capable of carrying 120KVA.

The secondary power bus carries 28V nominal unregulated DC, and is supplied by transformer-rectifier (TR) units that are tied into the 205V three-phase AC power of the primary system. This 'TR power' is used for control circuits, instruments, small motors and electronic equipment, and is backed up by two auxiliary nickel-cadmium batteries that supply 24V DC power to essential systems should the TRs fail. They also power emergency equipment through two dedicated battery buses.

Both AC and DC power are distributed via junction boxes and panels. Missile AC power is distributed through a dedicated missile power distribution box in the forward wheel well, but is derived from generator power boxes in engines 1, 3, 5 and 7. Meanwhile, missile DC control power comes from the aircraft's non-interruptible DC (NDC) bus. One TR unit also provides DC power for the rotary launcher hydraulic pump.

The generators are driven at a constant speed of 8,000rpm, and the minimum generator cut-in speed is approximately 5,670 engine rpm. Each generator drive has its own oil tank

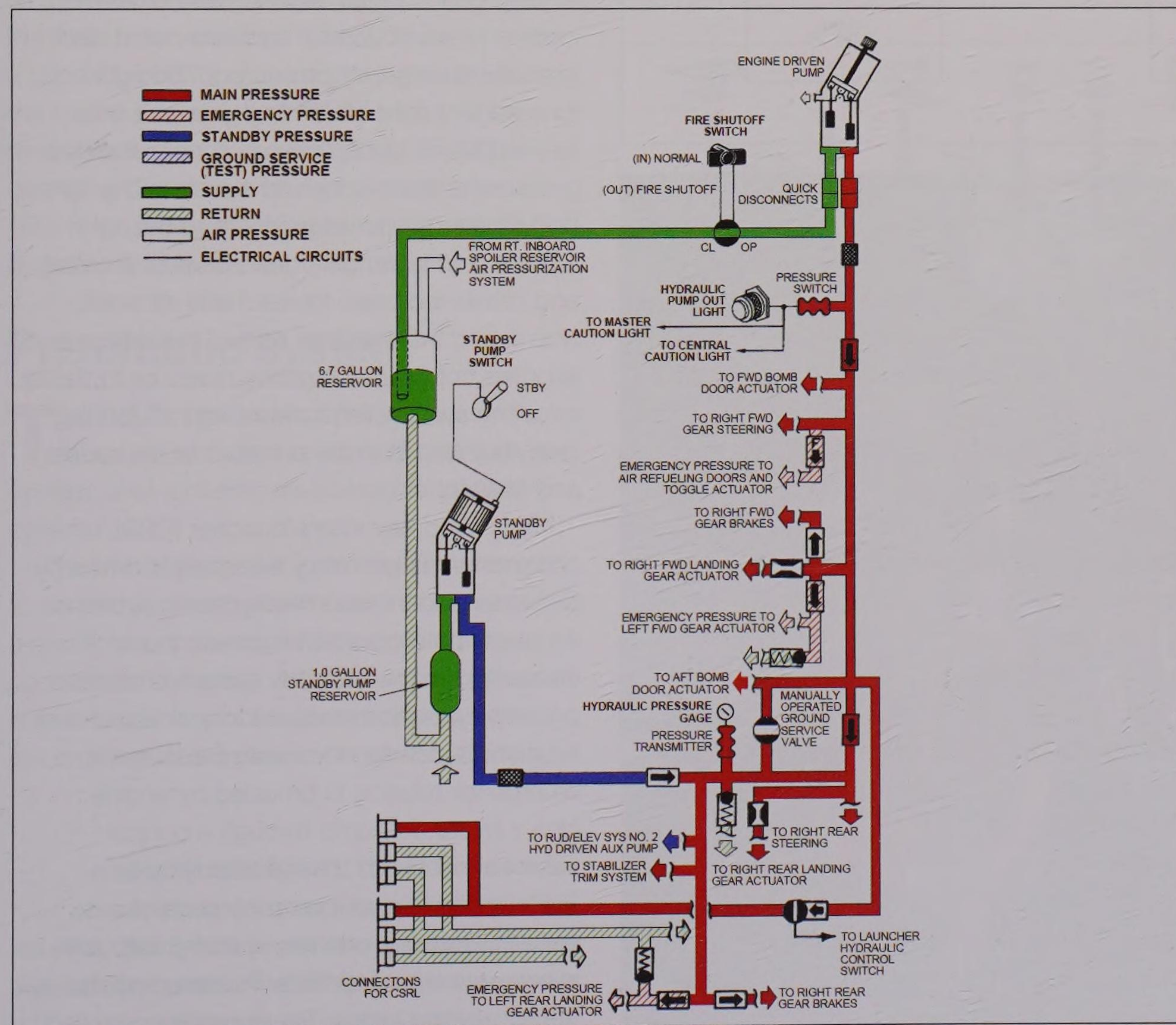
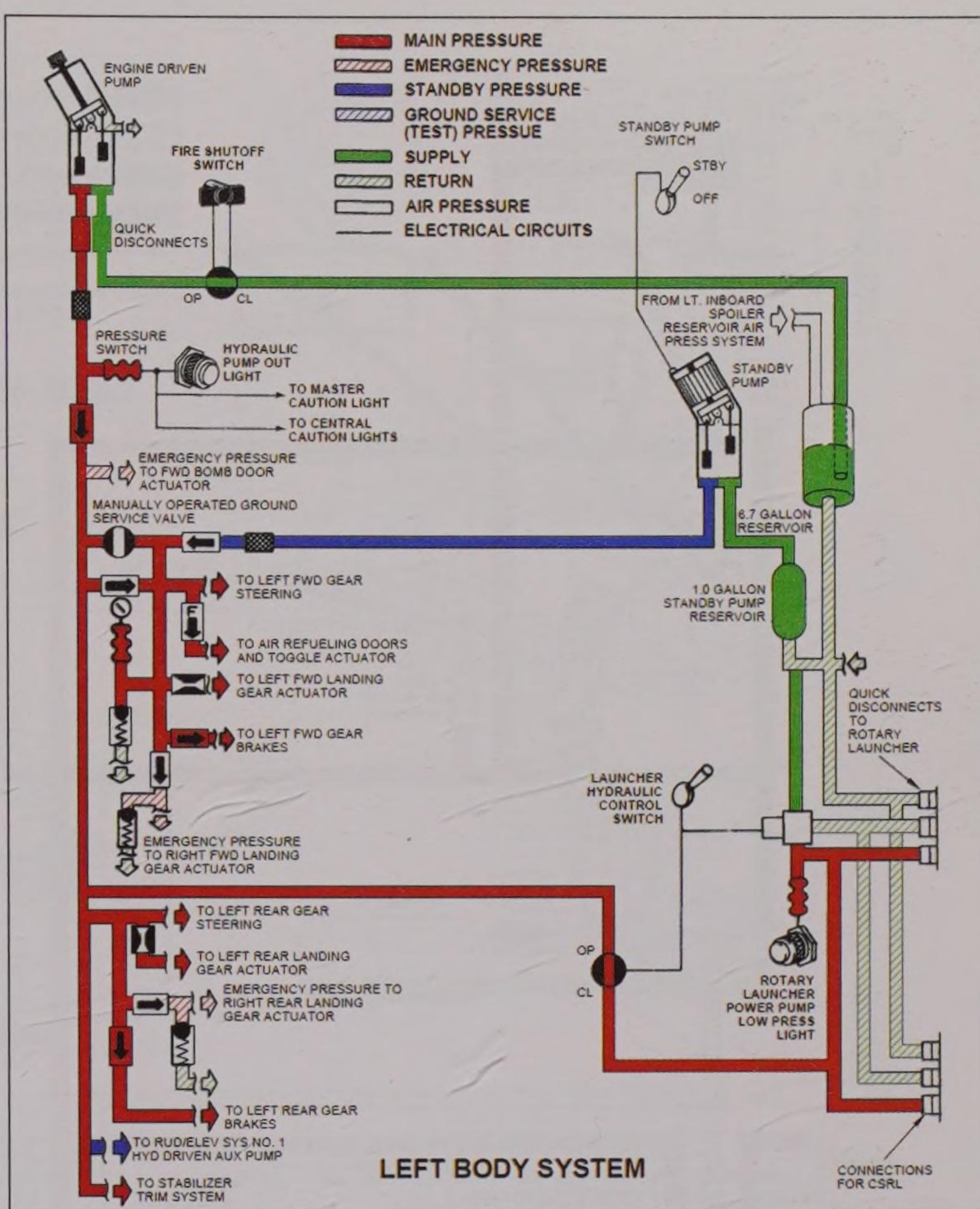
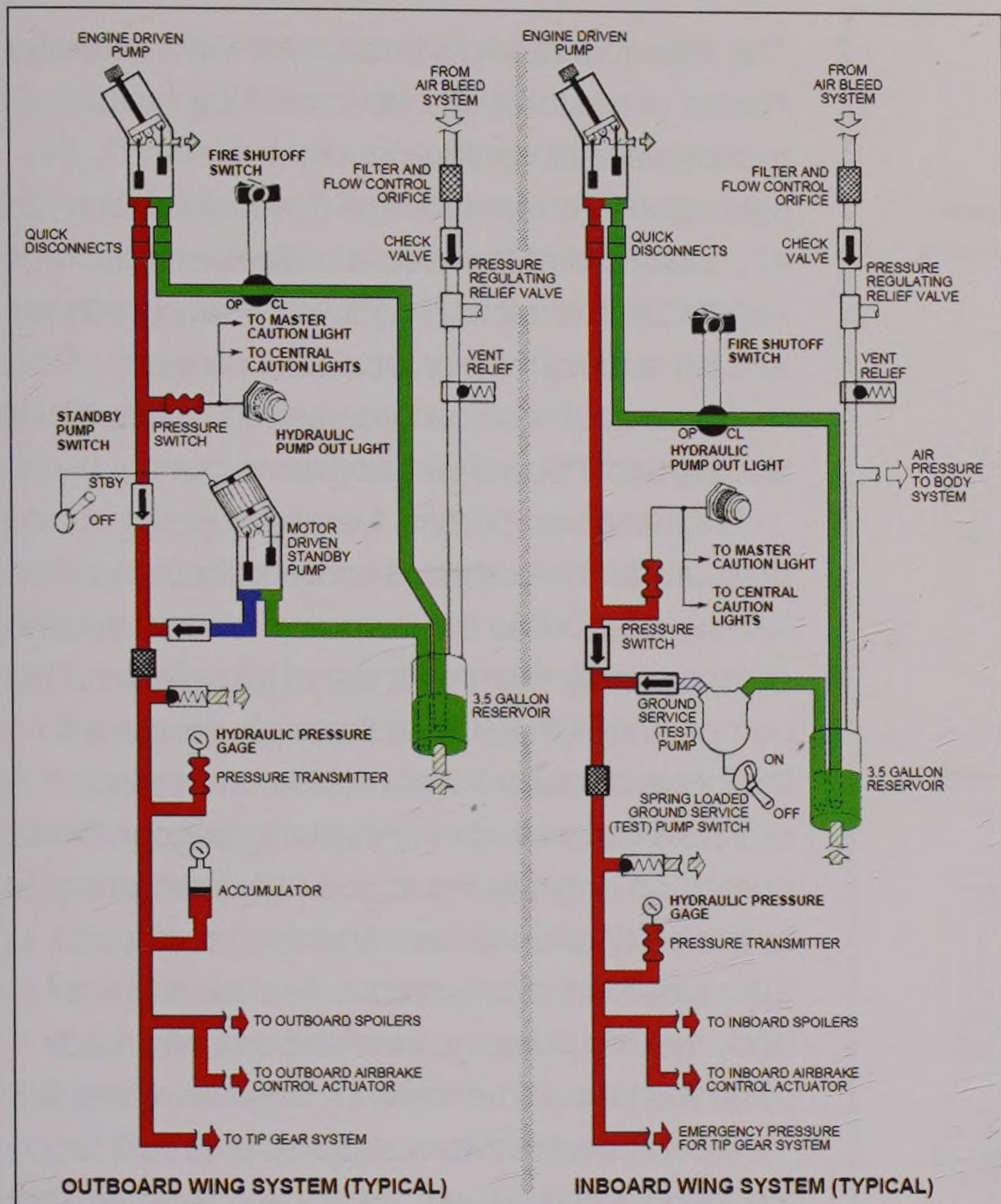
featuring a usable capacity of 6.75 quarts (total capacity is 9 quarts). The oil is routed through the generator drive, then through an oil cooler, before being returned to the tank. Cooling air for the oil cooler comes courtesy of the engine fan. Because some of the Stratofortress' electronic equipment requires constant frequency, the generator is driven at a constant speed throughout the range of various engine speeds. The constant speed drive that allows this consists of an hydraulic transmission controlled by an electro-mechanical governor. It adds to or subtracts from the variable input speed of the engine and provides a constant AC output from the generator of 400Hz (± 1).

Each generator features a number of protective features to either isolate it by tripping the respective bus tie circuit breaker, or put it into an 'underspeed' condition so that it turns at the slowest possible rate at any given engine speed. Similarly, if the constant speed drive's temperature reaches 250°F ($\pm 10^\circ$), the drive overheat light, master caution lights and central caution light will illuminate, signalling the pilots to decouple the device. They do so by controlling an electro-mechanical device that disconnects the drive input shaft from the engine shaft.

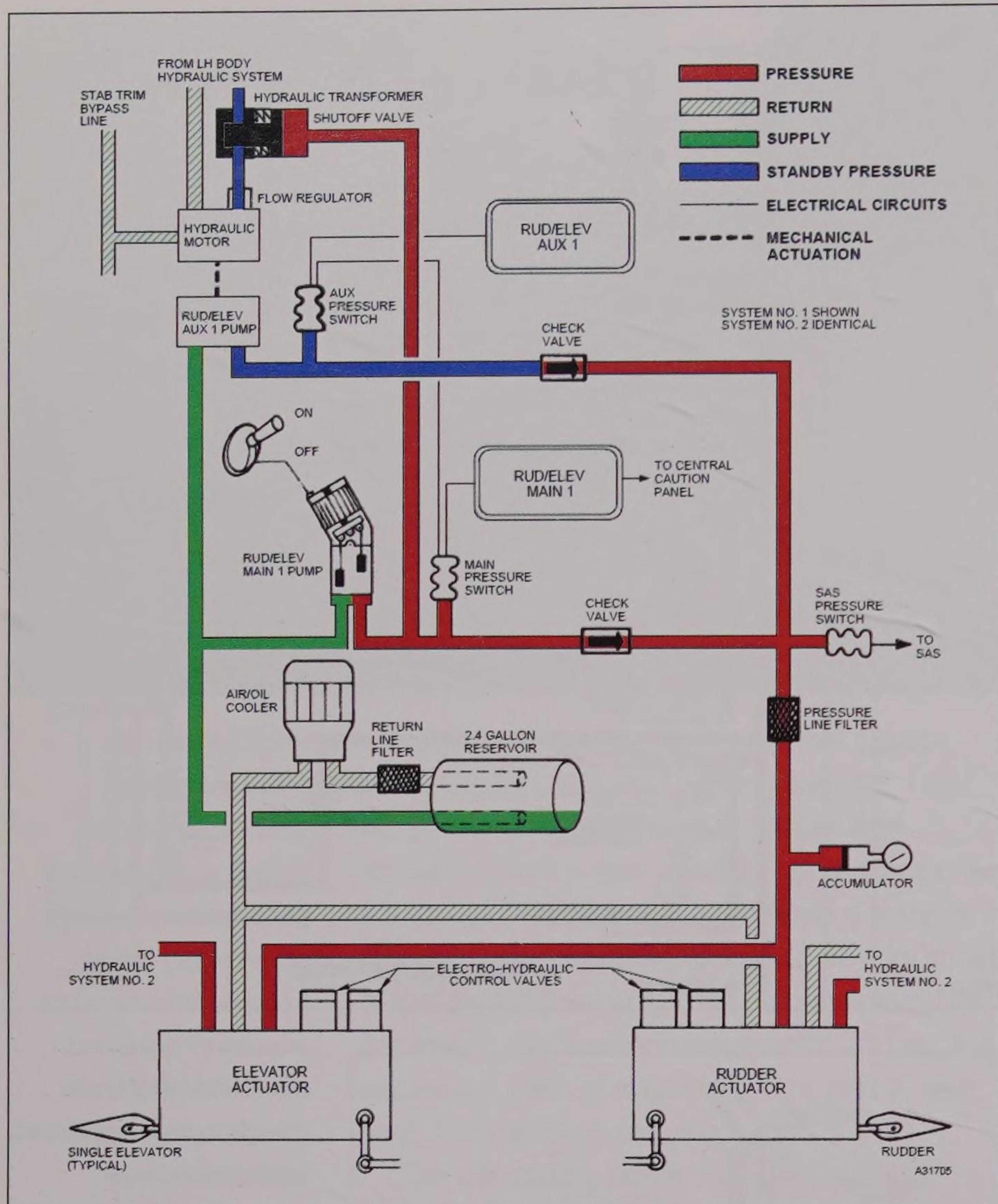
Hydraulic system

While most aircraft use a centralised hydraulic system split into left, right and auxiliary, the Stratofortress has a decentralised hydraulics configuration consisting of six independent, engine-driven systems: inboard and outboard systems in both the left wing and right wing, and right and left body. It is also equipped with two electric motor-driven primary hydraulic systems consisting of main No1 and No2, and a rudder/elevator hydraulic system. Although decentralising the hydraulics of the aircraft offers redundancy in its own right, the incorporation of alternate pressure sources adds an additional layer of robustness that ensures the continued operation of vital equipment during flight operations.

The workings of the four wing and two body systems is conventional insofar as they are each powered by engine-driven pumps mounted on the right side of engines 1, 3, 4, 5, 6 and 7.



THIS PAGE The Stratofortress features a decentralised hydraulics configuration consisting of six independent, engine-driven systems: inboard and outboard systems in both the left wing and right wing, and right and left body. Here, the schematics for the two wing systems [above, left] and the left- and right-body systems [above/left] show the configuration of supply and return hydraulic lines and associated components. (USAF)



ABOVE The hydraulic system for the elevator and rudder includes a 2.4-gallon reservoir of hydraulic fluid. (USAF)

RIGHT The CSRL is equipped with two independent hydraulic systems, with the left body system providing primary hydraulic pressure. Here, live AGM-86C CALCMs are loaded on to the rotating launcher. (USAF)



The electric motor-driven pumps, which supply normal pressure to the No1 and No2 main rudder/elevator hydraulics, are mounted on the right aft side of the fuselage (fuselage station 47). Electric motor-driven standby pumps, installed at the left and right wing trailing edges and left and right body locations, provide redundancy. These can be used to power all but the two inboard wing systems.

Engine-driven pumps 1 and 7 supply pressure to the outboard spoilers and wingtip landing gear, while the outboard left and right pumps supply them with standby pressure. The pumps on engines 3 and 6 supply pressure to the inboard spoilers and provide emergency pressure for extension of the wingtip gear. The pumps on engines 4 and 5 supply pressure to the body systems and standby pressure to the rudder/elevator systems. The left and right body electric pumps power the essential body systems normally serviced by engines 4 and 5.

The left body system supplies pressure to the air refuelling system, left forward and aft landing gear, brakes, steering and crosswind crab, and the horizontal stabiliser nut. It also provides emergency pressure to the right forward and right aft landing gear and the forward bomb door, and can supply standby pressure to the rudder and elevator. The right body system supplies pressure to the right forward and aft landing gear, brakes, steering and crosswind crab, forward and aft bomb doors, and the stabiliser screw. In addition it supplies not only emergency pressure to the air refuelling system, left forward and aft landing gear, but also standby pressure to the rudder and elevator.

The bomb bay rotary launcher (CSRL – common strategic rotary launcher) is driven by two independent launcher hydraulic systems. An electric motor-driven hydraulic pump connected to the left body system provides primary hydraulic pressure for normal launcher rotation. Secondary hydraulic pressure for emergency rotation is provided by engine No5's hydraulic pump through a control valve connected to the right body system. The launcher power pump consists of a piston pump that can vary delivery output. It is powered by a 115/200V AC three-phase 400Hz electric motor. The pump is controlled by

activating the rotary launcher switch located on the pilot's hydraulic control panel.

Each variable delivery engine-driven pump has a rated flow of 12 gallons per minute, outputting hydraulic fluid at 2,800psi. Should any pump reach a cut-out pressure of 3,000psi (± 50), the pump will continue to operate but the fluid itself will be bypassed. Each electric motor-driven standby pump has a flow of three gallons per minute at an output of 1,300psi. Variable delivery standby pumps, which discontinue delivery at a cut-out pressure of 3,000psi (± 50), are controlled from the pilot's side panel.

The standby pumps are 205V 400Hz AC constant speed electric motors coupled to variable speed hydraulic pumps that have an output of three gallons per minute at 1,300psi or 1.2 gallons per minute at 2,800psi. Cut-out pressure of each standby pump is 3,000psi (± 50).

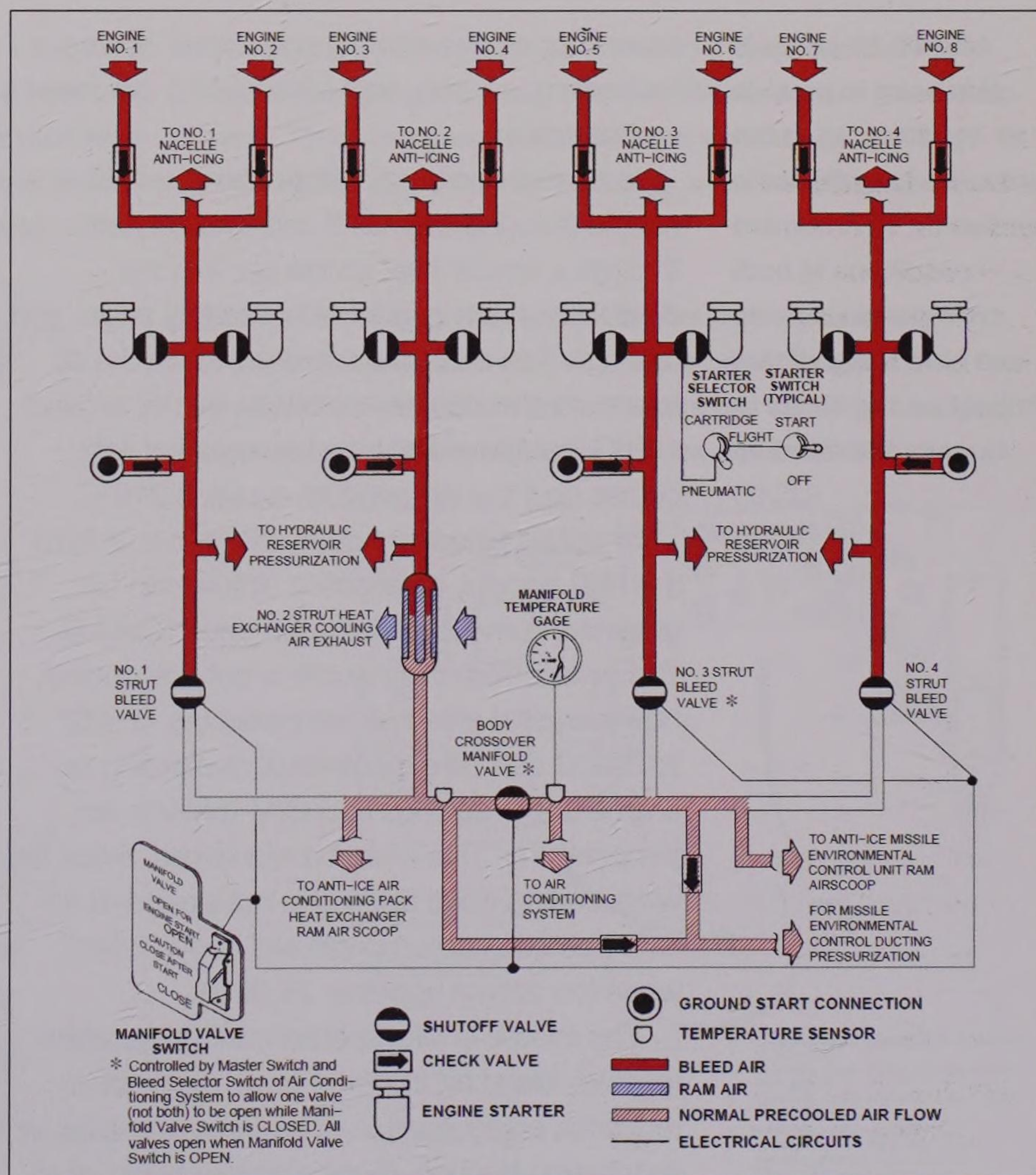
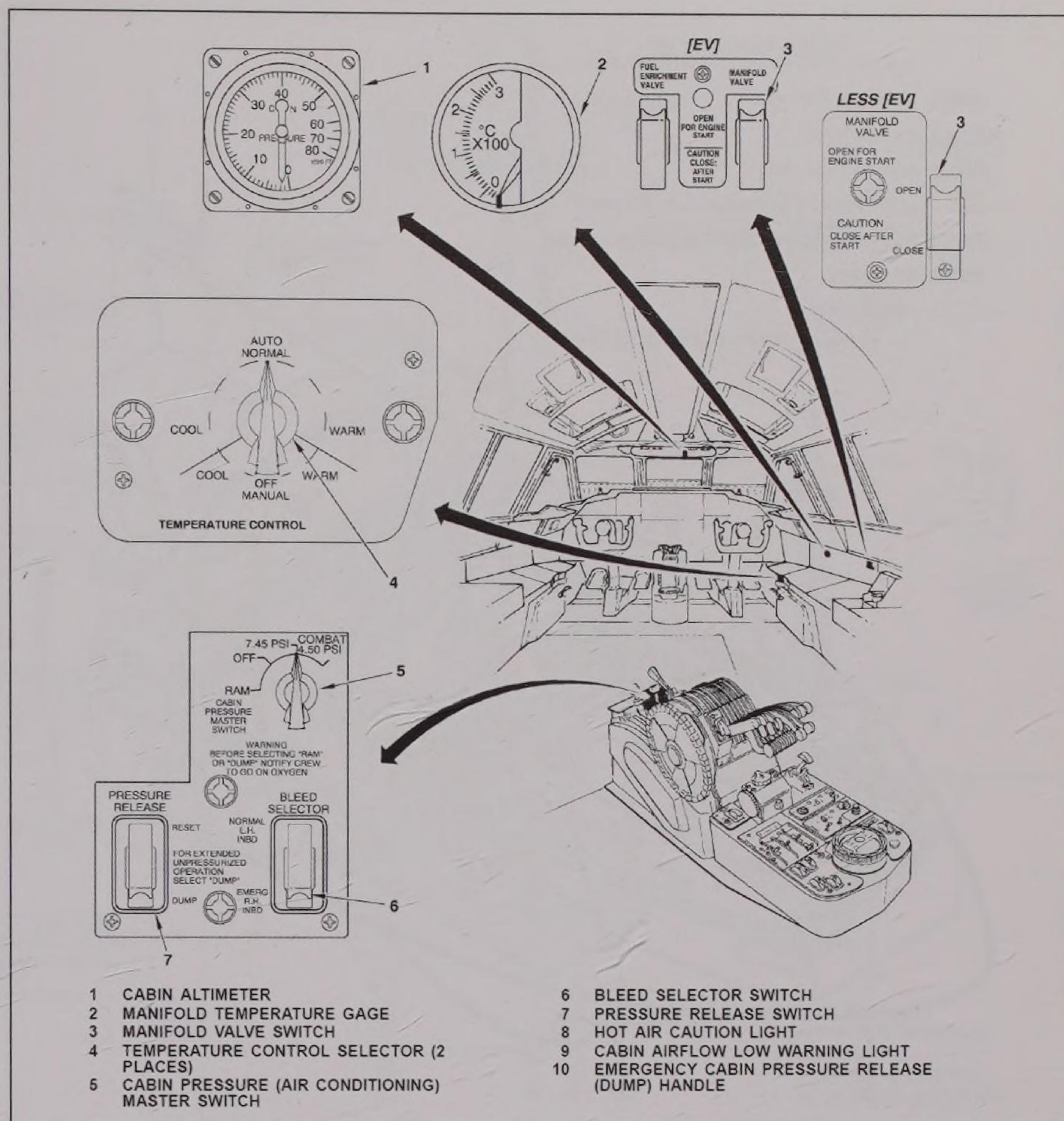
Each wing hydraulic system includes a 3.5-gallon reservoir located in the wing trailing edge. The outboard reservoirs supply fluid for the electric motor-driven standby pumps as well as the main engine-driven pumps. Meanwhile, the main reservoirs for the body system have a capacity of 6.7 gallons and are located in the trailing edge of the inboard wings. These reservoirs are each pressurised at 25–30psi operating pressure, and each has an internal 100in³ 'negative g tank' to keep a supply of hydraulic fluid available during negative g flight.

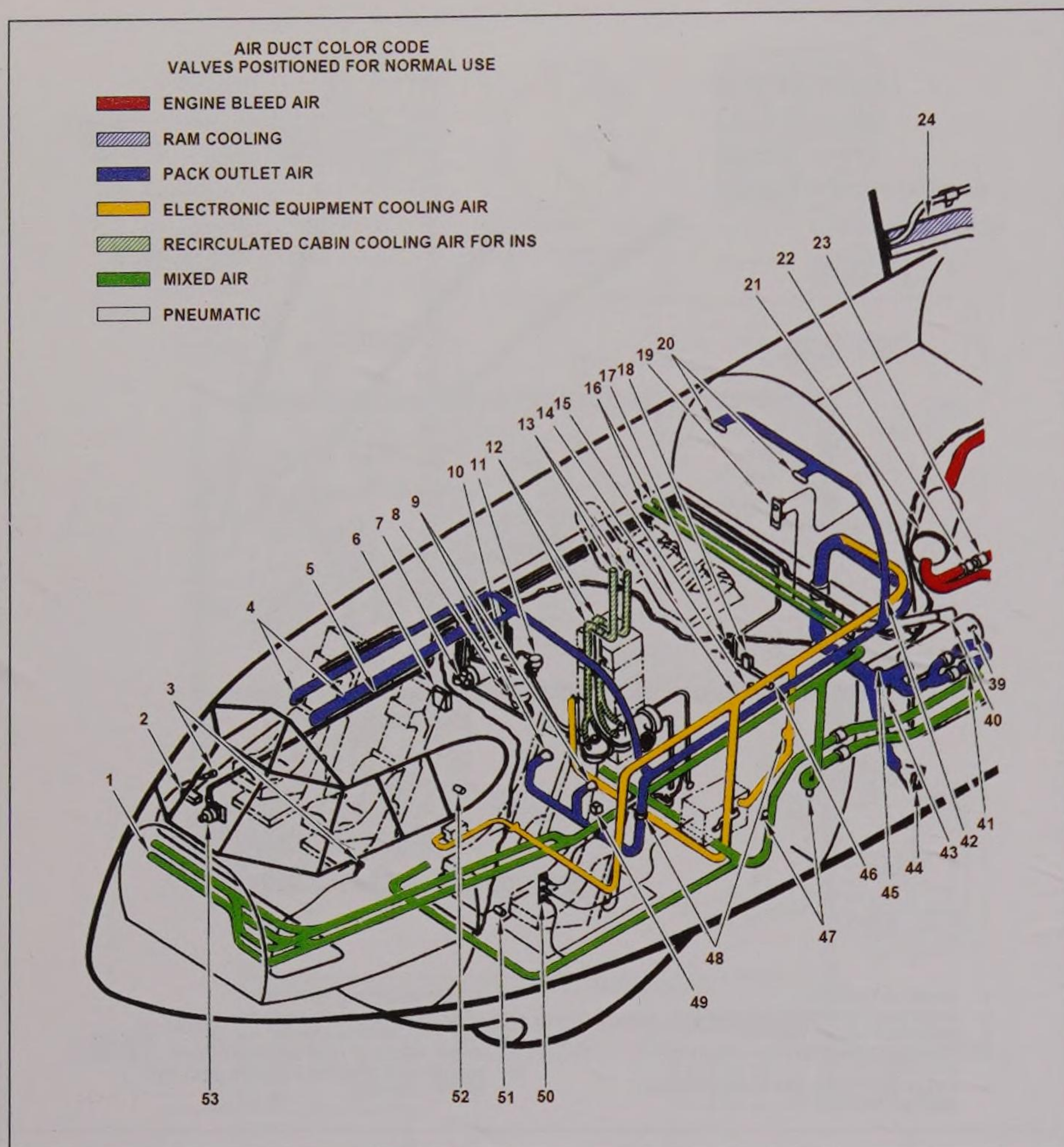
Pneumatic system

The B-52's pneumatic systems include a bleed air, air conditioning and pressurisation system, and a missile environmental control system.

The bleed air system is technically referred to as the 'air bleed system', and incorporates a manifold in the wing leading edge and controls for collecting and routing high pressure hot air from the final stage compressors of the engines. This system acts as the power

ABOVE AND RIGHT The controls for the pneumatic system are located in front of the co-pilot. The B-52's pneumatic systems include a bleed air and pressurisation system, and a missile environmental control system. (USAF)





ABOVE Bleed air is also used to provide air conditioning to the crew. On long flights in particular, environment conditions in both crew compartments can have a significant impact on the ability to execute the mission. (USAF)

source for engine starting and the air source for heating, cooling, and pressurising the crew compartment.

In normal operation, airflow from the No2 nacelle (housing engines 3 and 4) is passed through a ram air heat exchanger into the distribution ducting in the wing leading edges and fuselage. The heat exchanger pre-cools the air to ensure that duct temperatures do not exceed 190°C, but the pilots' bleed air overheat light comes on if the temperature exceeds 210°C.

Should a bleed air supply failure occur from the No2 nacelle, emergency airflow can be obtained from No3 nacelle (engines 5 and 6). The airflow from this nacelle is not pre-cooled, however, and bleed air temperatures of 232° to 399°C can be experienced, depending on engine thrust settings and OAT (outside air temperature). This must be monitored, since the wing leading edge ducting is not designed for safe operation at temperatures above 246°C when the aircraft is below 25,000ft.

The missile environmental control system receives bleed air from the body manifold. It regulates pressurisation of the environmental air distribution ducting. Right manifold bleed air is

supplied to a valve for anti-icing of the missile ram air scoop in the right wing leading edge. The bleed air from all four nacelles provides pressure to the hydraulic reservoir tanks.

Landing gear, crosswind crab and steering systems, wheel brake and drag chute

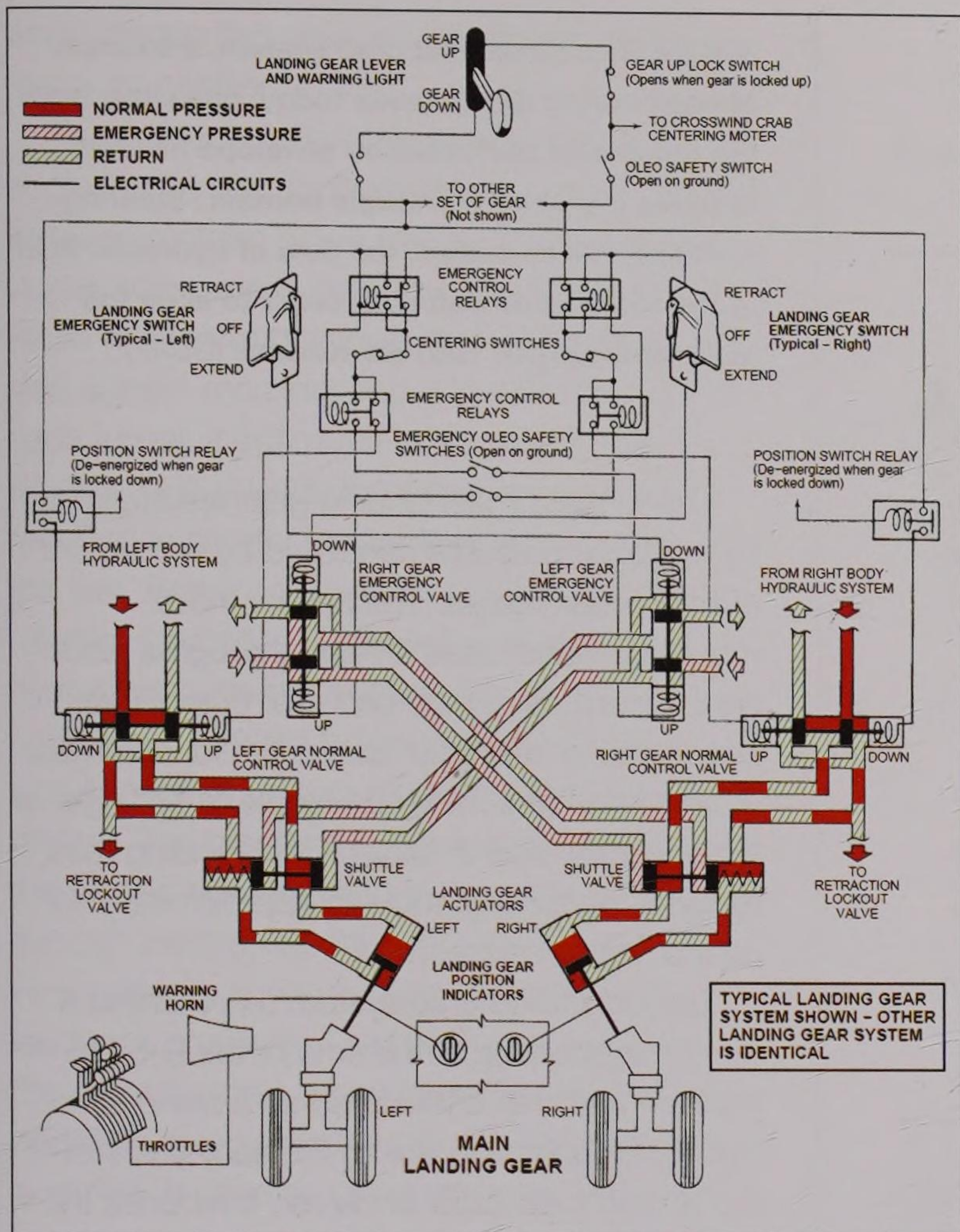
The Stratofortress' landing gear is made up of a main landing gear system and the tip gear system, all of which are hydraulically actuated through electrically operated valves.

The dual-wheel main landing gear is arranged as a quadricycle, meaning that there are two gear side-by-side forward and two aft. The forward gear retract forwards into fuselage wheel wells; the aft gear retracts aft. The main landing gear doors are mechanically linked to the gear.

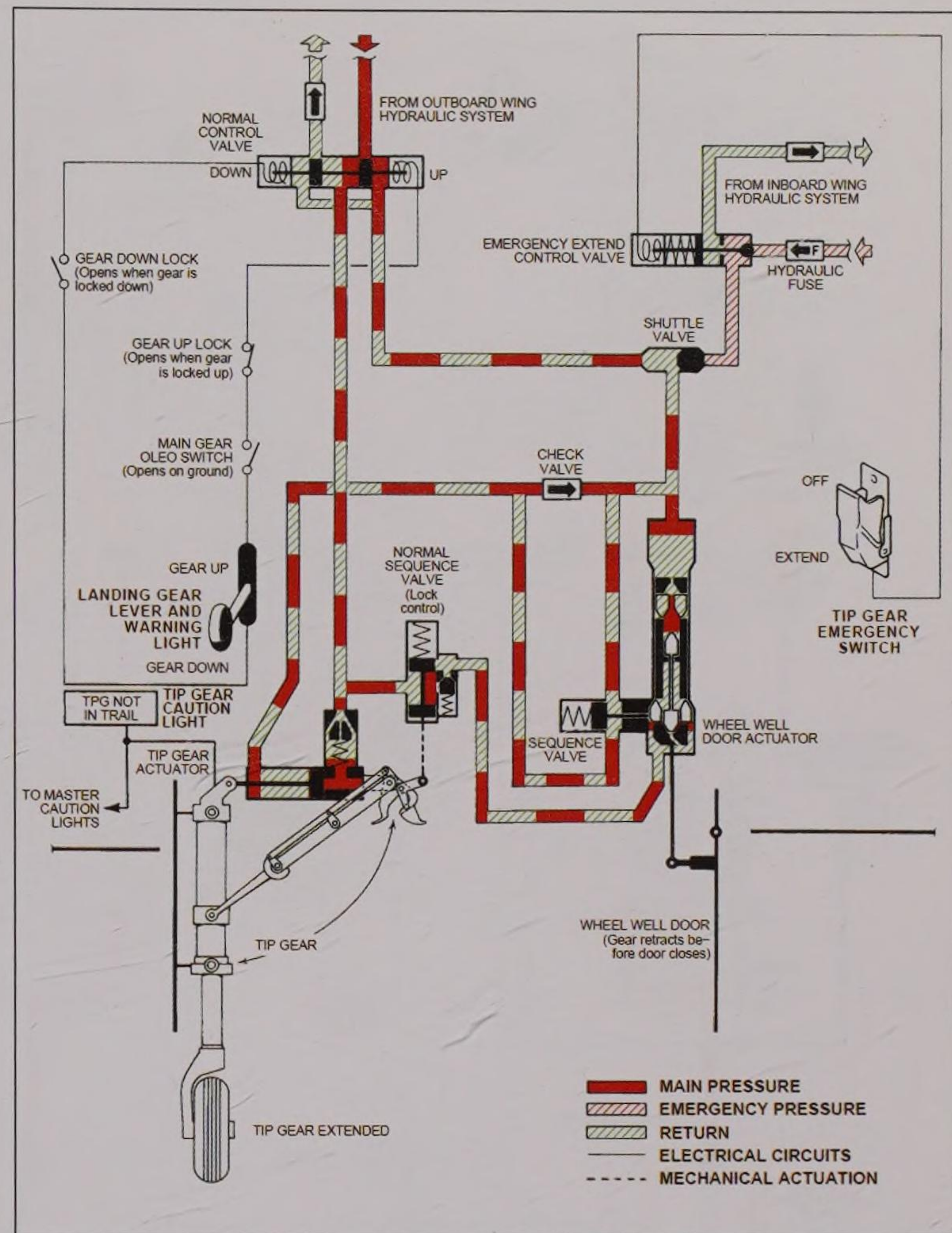
The tip gear are located between the outboard engine strut and the external fuel tank strut, retracting inboard and slightly forward into each wing. These two outriggers prevent damage to the wingtips when the aircraft is at high gross weight – the only time the tip gear normally make contact with the ground. They also protect against wingtip ground strikes during taxi, take-off and landing, when aggressive turning or wind gusts can cause the aircraft to rock. The tip gear follow the cycle of operation for the main gear.

Retraction and extension of the landing gear is accomplished by hydraulic actuators pressurised by the right and left body hydraulic systems. The landing gear is fully retracted in 10–15 seconds and extends over the same amount of time. A single mechanical lock on the main landing gear drag strut locks the main landing gear in either the extended or the retracted position.

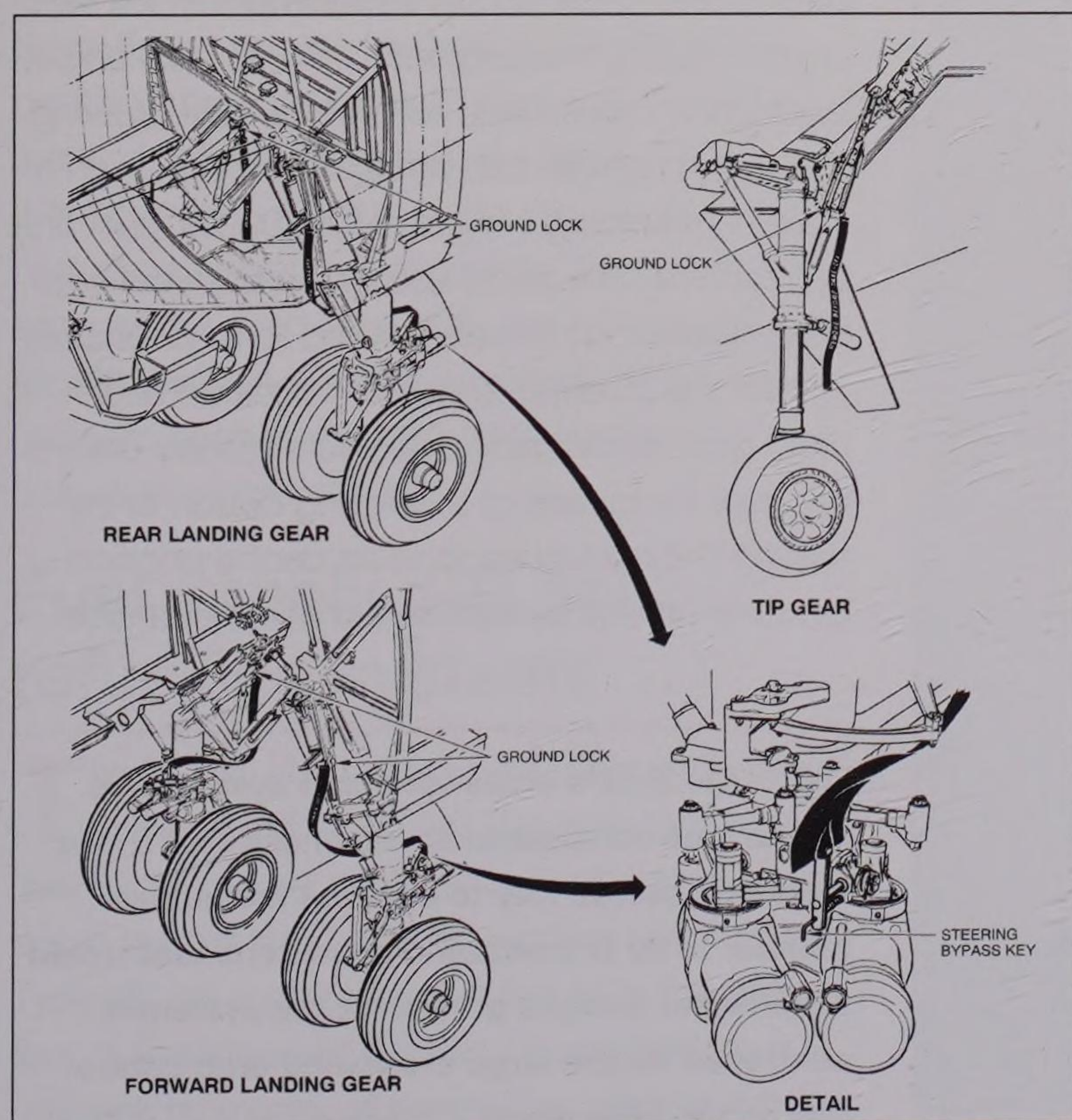
The 'steering' and the 'crosswind crab' systems allow steering of the aircraft on the ground and the presetting of a landing gear crab angle during crosswind landings and take-offs. Both systems are integrated through mechanical and cable linkage to a coordinating unit, from which metering valves on both forward and aft main gear are set.



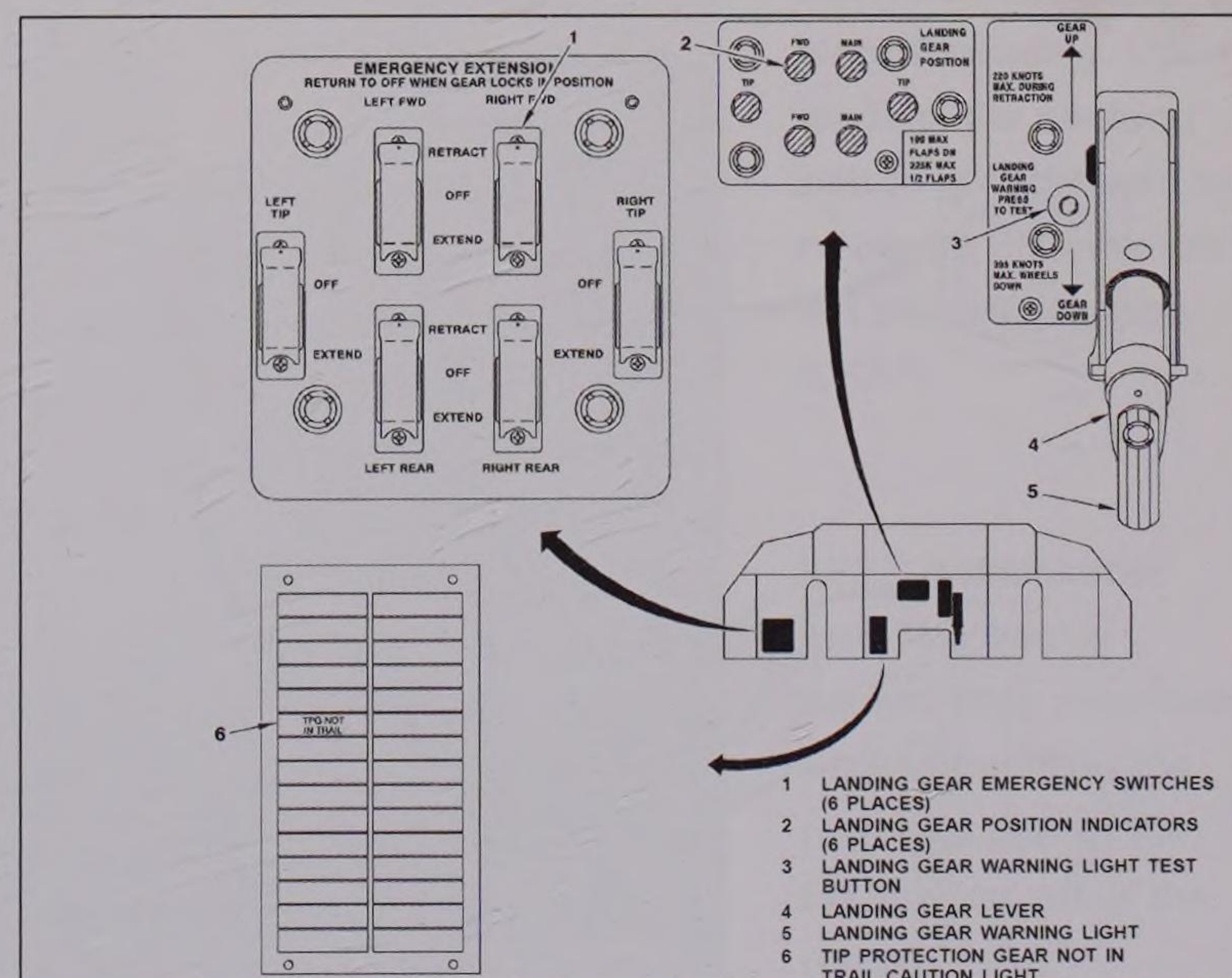
ABOVE The B-52 has two landing gear systems – the main gear, split into fore and aft, and the tip gear. The latter are intended primarily to prevent the aircraft's wingtips from scraping the ground during taxi manoeuvres, but are not otherwise designed to be load bearing. (USAF)

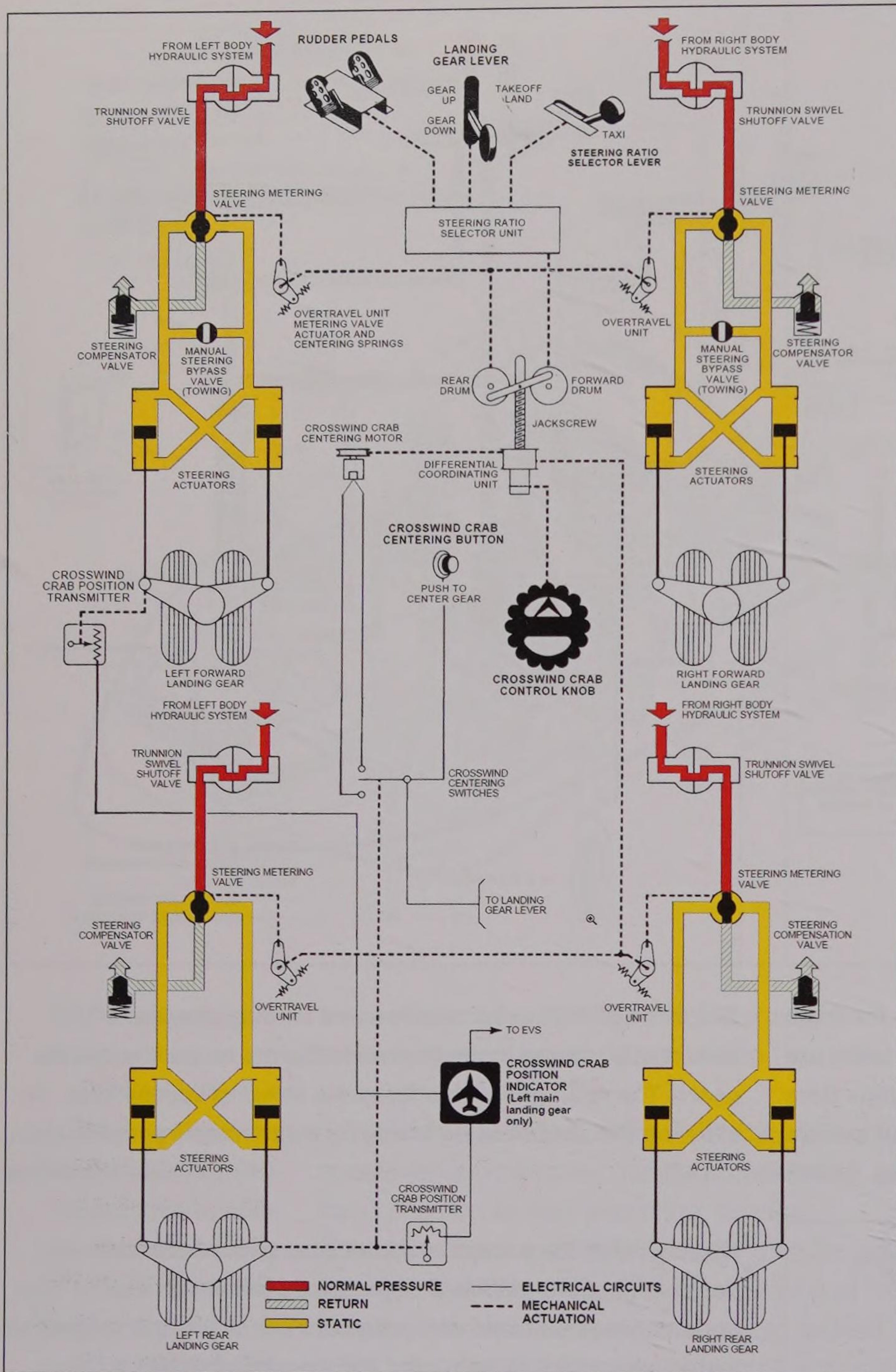


BELOW LEFT The rear and forward landing gears are individually ground locked between flights, as are the two tip gears. The main gears also feature a steering bypass key, allowing the aircraft to be towed by maintenance personnel. (USAF)



BELOW With the exception of the emergency extension controls (located outboard of the pilot's left knee), the undercarriage controls and indicators are sensibly arranged within easy reach of both pilot and co-pilot. (USAF)

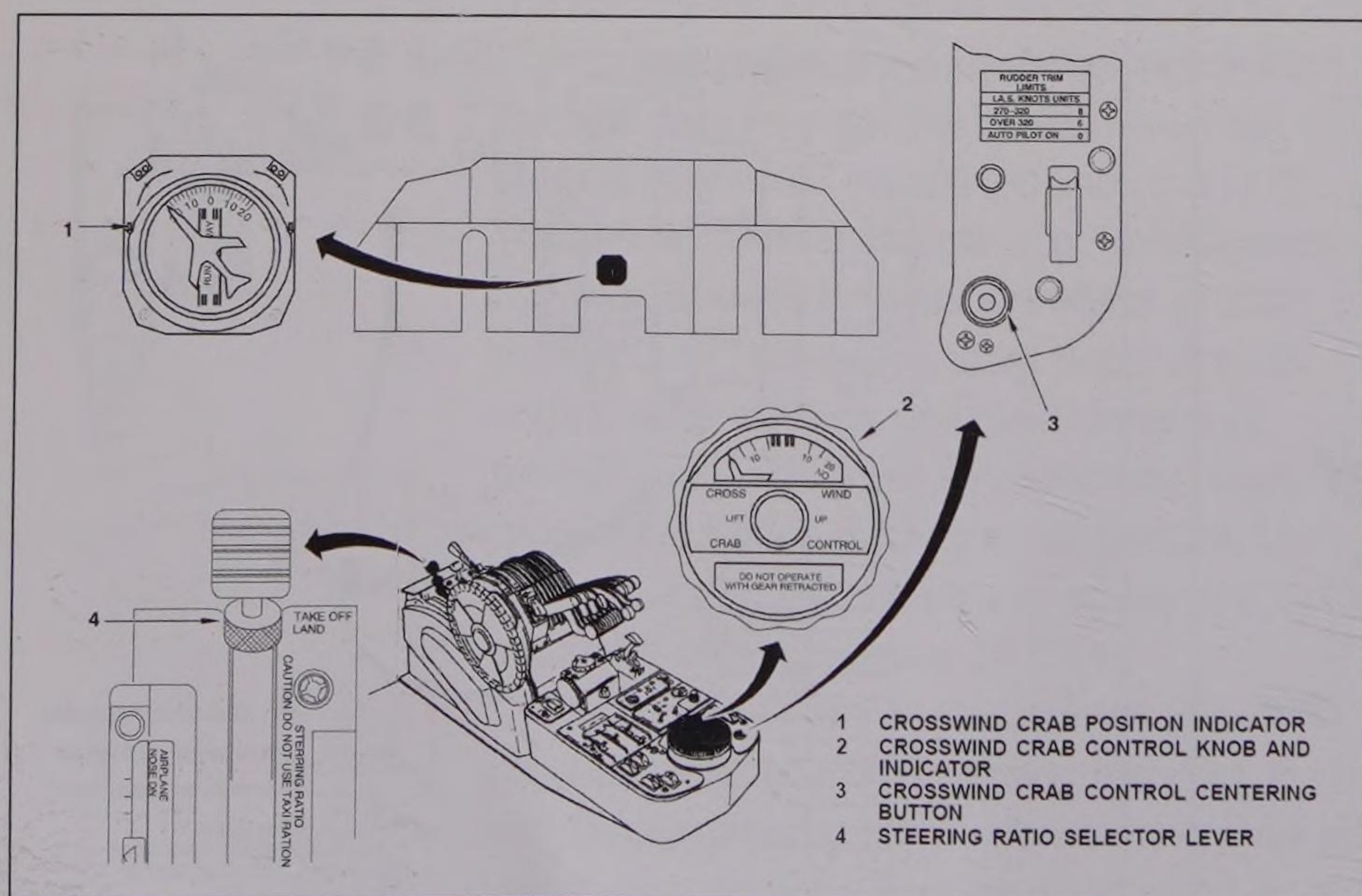




ABOVE The crosswind crab system, a triumph of engineering design even today, gives the B-52 the crosswind performance envelope needed to make it a potent strategic bomber. Steering metering valves control the flow of hydraulic fluid to the steering actuators in order to align the main landing gear with the runway. (USAF)

The forward main landing gear are steered by hydraulic pressure controlled by movement of the rudder pedals. The pedals move mechanical and cable linkage through a ratio selector unit set by the pilots for one of two conditions: a 'taxi ratio' allows the forward gear to be turned to a maximum angle of 55° right or left of centre, and a 'take-off and landing ratio' restricts the turning angle to approximately 12° right or left of centre.

The crosswind crab system represented a feat of engineering at the time of the B-52's creation and was considered so advanced that it was classified during the early years of the aircraft's operational career. It reduces the hazards associated with crosswind take-offs and landings, turning all four main gear to align with the runway while the aircraft is flown wings-level to compensate for drift. The system utilises the steering actuators on the front and aft main gear, allowing the pilots to dial in a preset gear deflection of a maximum of 20° left or right during the approach. At 20° crab angle, landings in crosswinds as high as 43kt blowing 90° to the runway can be achieved, although a maximum landing weight of 270,000lb must first be reached. The pilots use the 'crosswind crab control knob' on the aisle stand to mechanically control the steering metering valves on each main gear. On landing, the pilots quickly centre the gear by means of a centring button or by turning the control knob to its centre position. On take-off, the system automatically centres



LEFT The B-52's crosswind crab system was at one time considered so advanced that it was classified secret. Key to allowing the nuclear bomber to fly in crosswind conditions that would keep lesser designs grounded, the system is controlled via the large crosswind crab control dial on the aisle stand. (USAF)

when the landing gear lever is moved to the 'gear up' position.

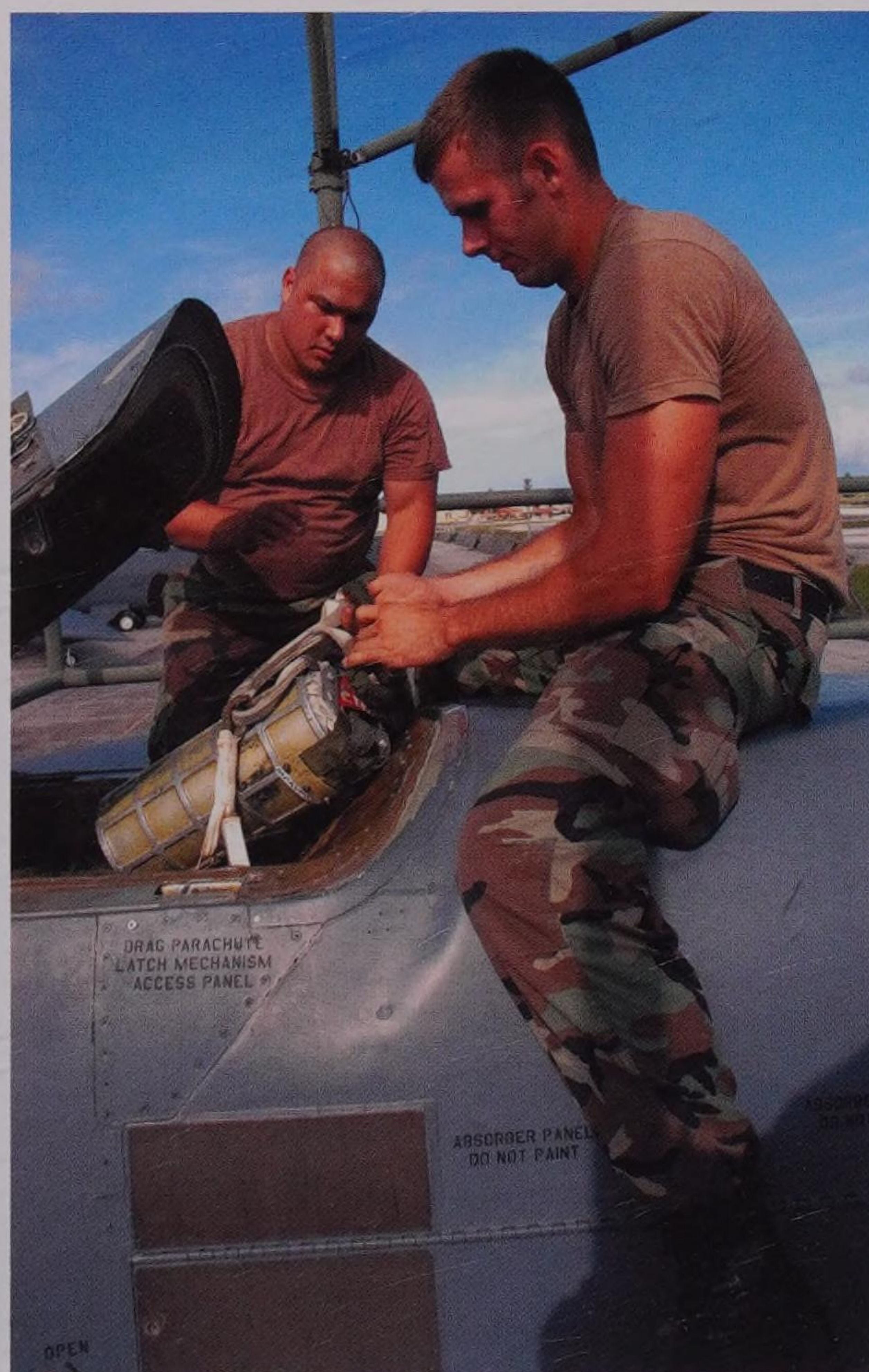
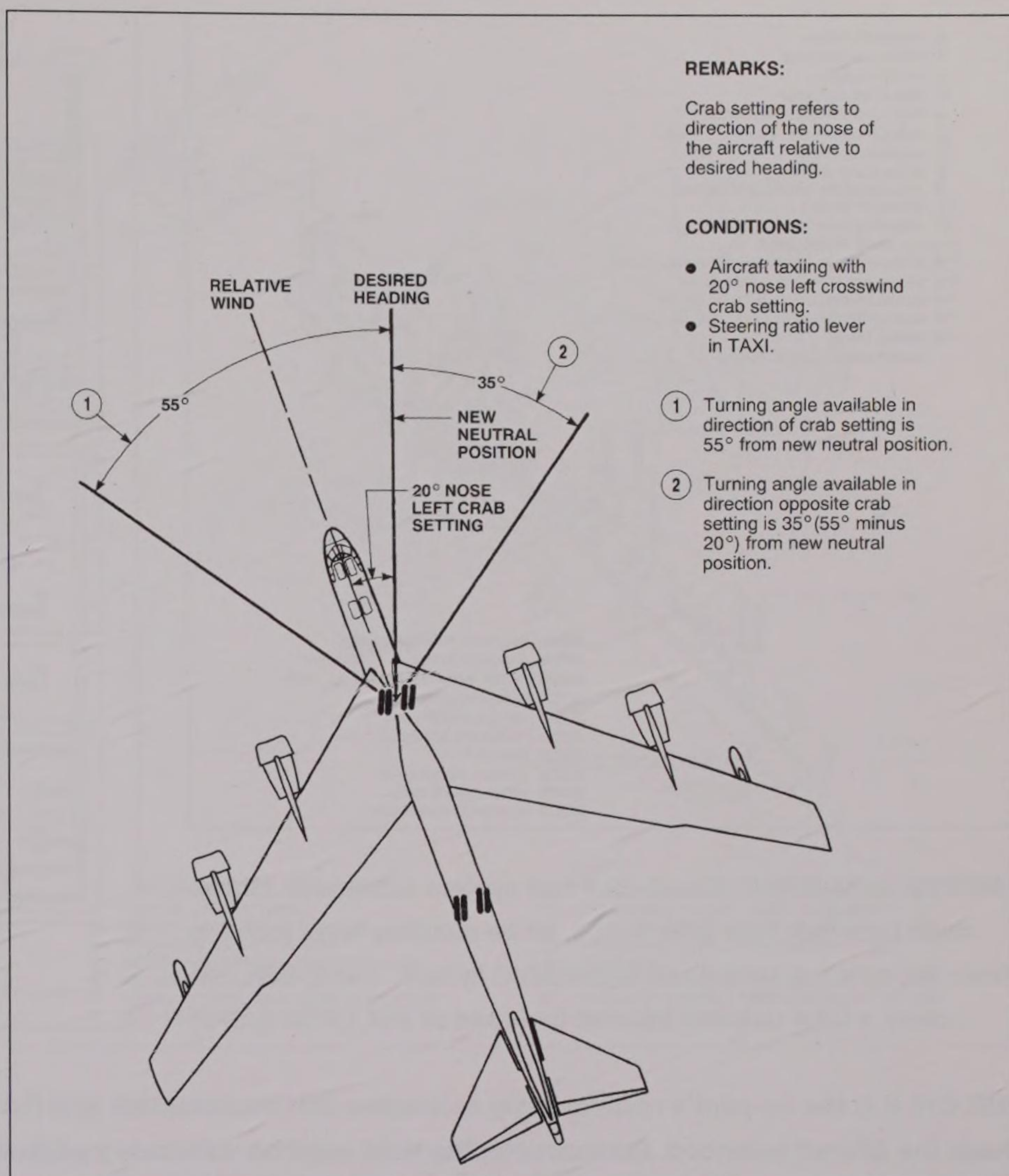
Each wheel of the main landing gear has segmented rotor, multiple-disc hydraulic brakes with cerametallic brake linings. These activate in accordance with pressure on rudder pedals. While differential braking is not possible, an anti-skid system monitors and corrects skidding for each wheel. It optimises braking and prevents skids at high speed under light wheel loads, resulting in shorter stopping distances even in the wet. Brake pressure for the left and right wheels is supplied by the left and right body hydraulics systems respectively.

The two forward brakes are actuated simultaneously, in turn triggering the two rear brakes. Toe pressure applied by the pilots to the pedals is transmitted to two metering valves through mechanical linkages, and the pedals incorporate a spring system to create pedal feedback pressure. The aisle stand between the pilots features a parking brake to lock the pedals in the 'applied position' when the aircraft is at rest. It does so using pressure from the accumulators installed in the wheel well of each main wheel (one per wheel).

Finally, the B-52 pilots can deploy a 44ft-long ribbon-type drag parachute for deceleration during the landing roll. Installed in a compartment aft of the rudder in the top of the tail section, its operation is simple: the pilots move the drag chute lever from the 'locked' to the 'deploy' position, the compartment door opens, and a spring-loaded pilot chute is released into the slipstream, thereby deploying the main parachute behind the aircraft as it does so. The risers of the main parachute are attached to the aircraft through a jettison mechanism; the lever's 'jettison' position releases the parachute for collection by ground crew.

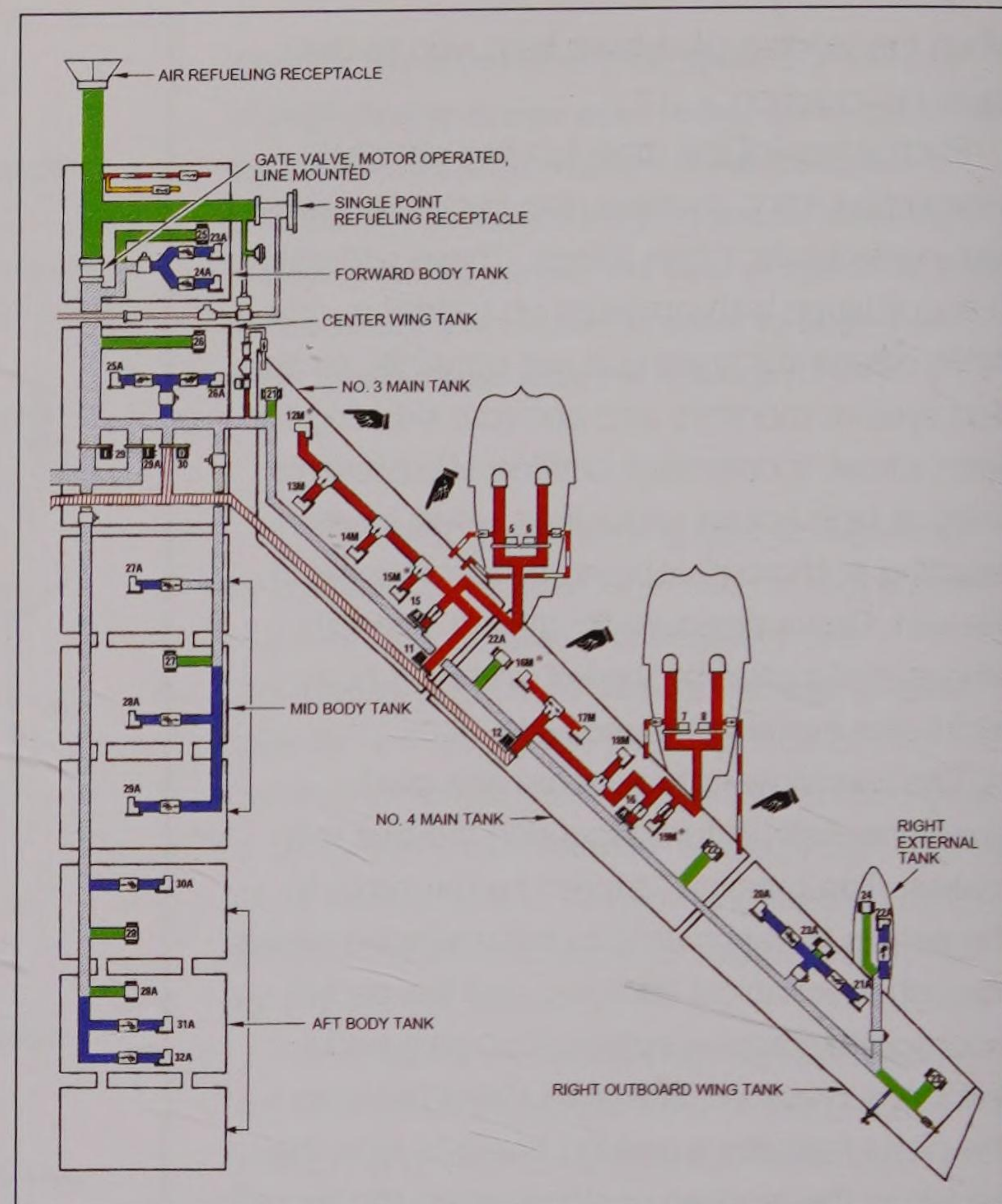
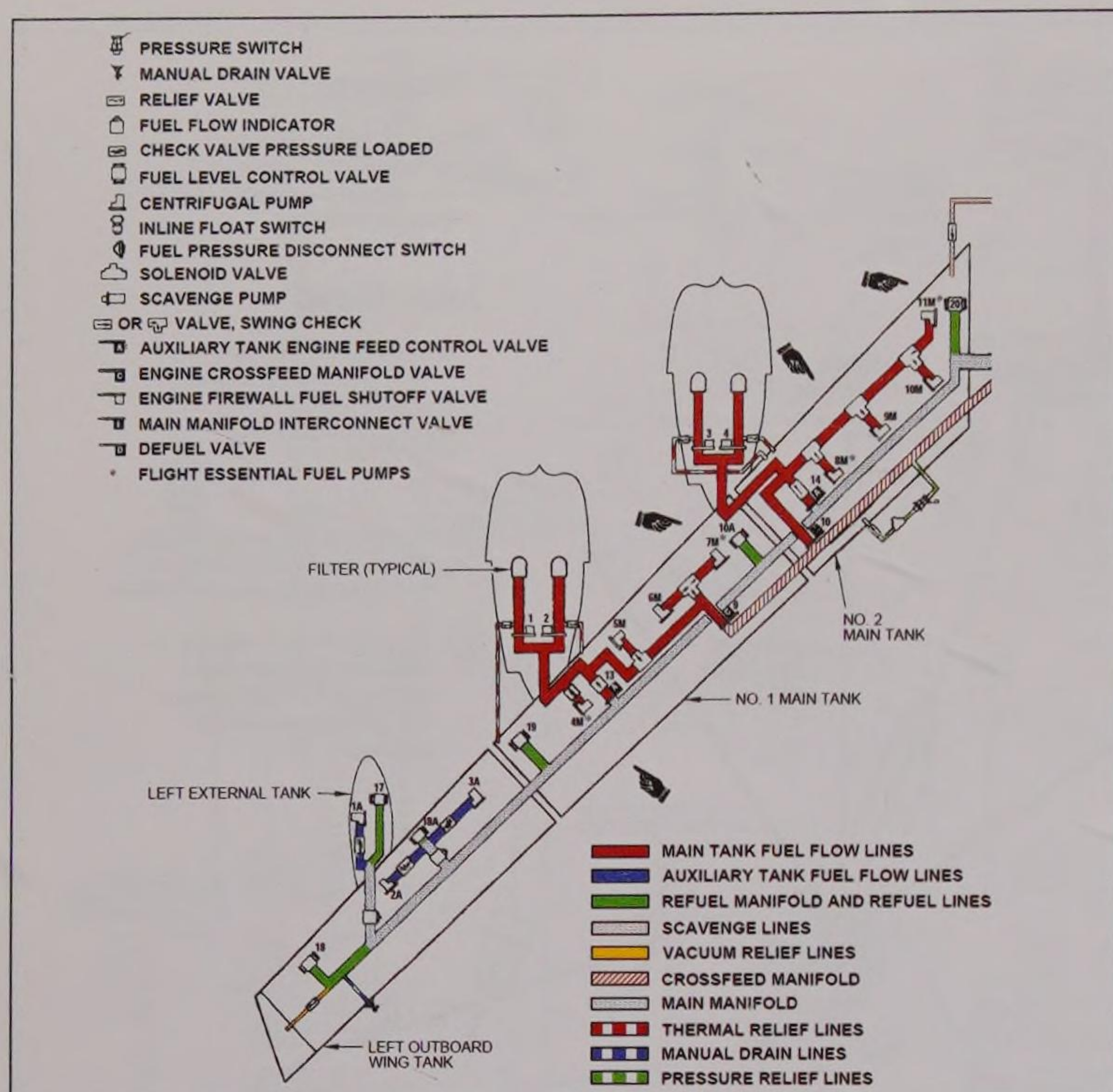
Fuel supply, CG and refuelling systems

The B-52H can carry a total useable internal fuel load of 312,197lb. The main tanks are 'wet wing' integral wing tanks; each has four boost pumps and normally supplies two engines. Typically the engines receive fuel from the nearest four main tanks, but fuel can be supplied from any tank by means of a pressure override in the



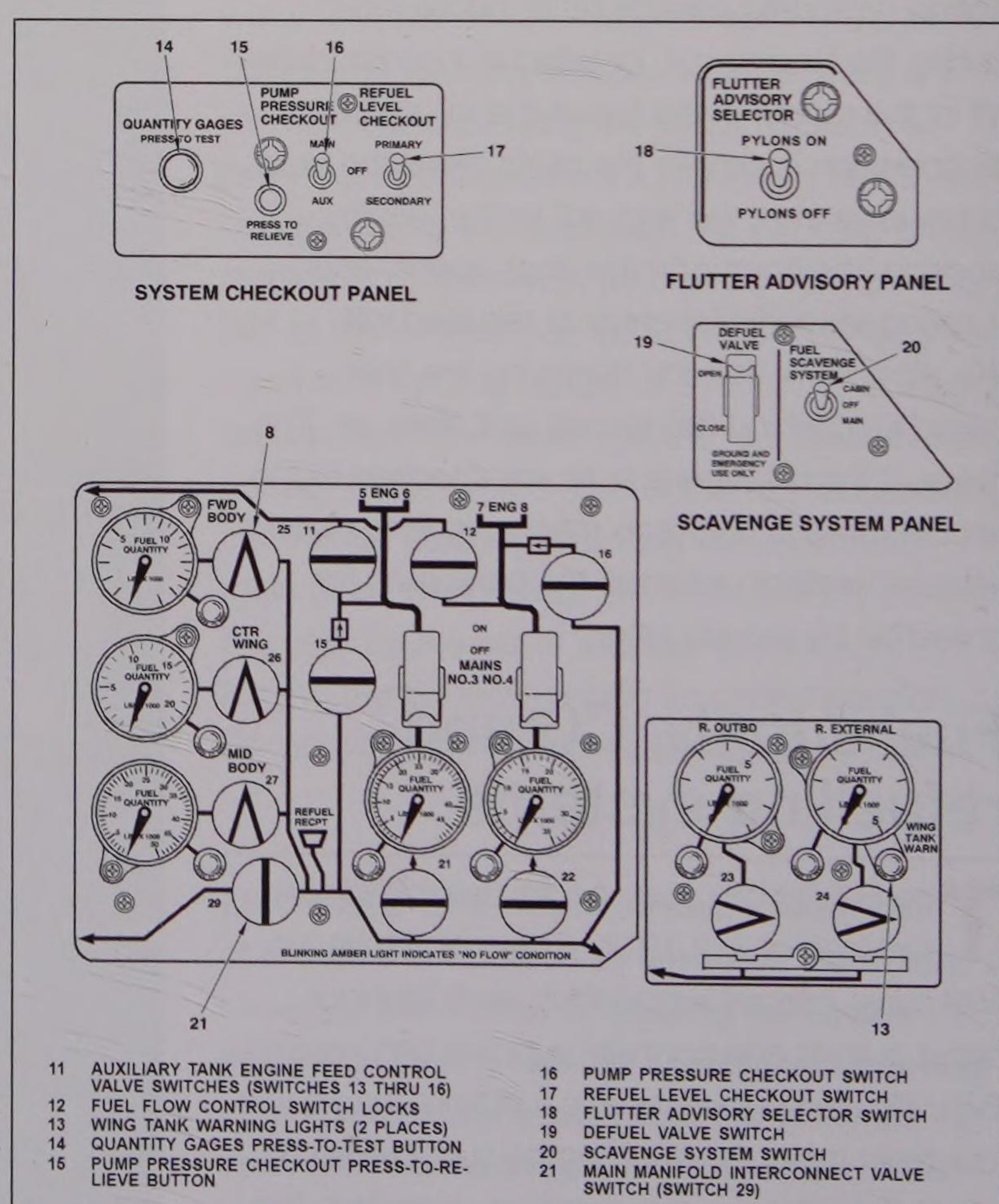
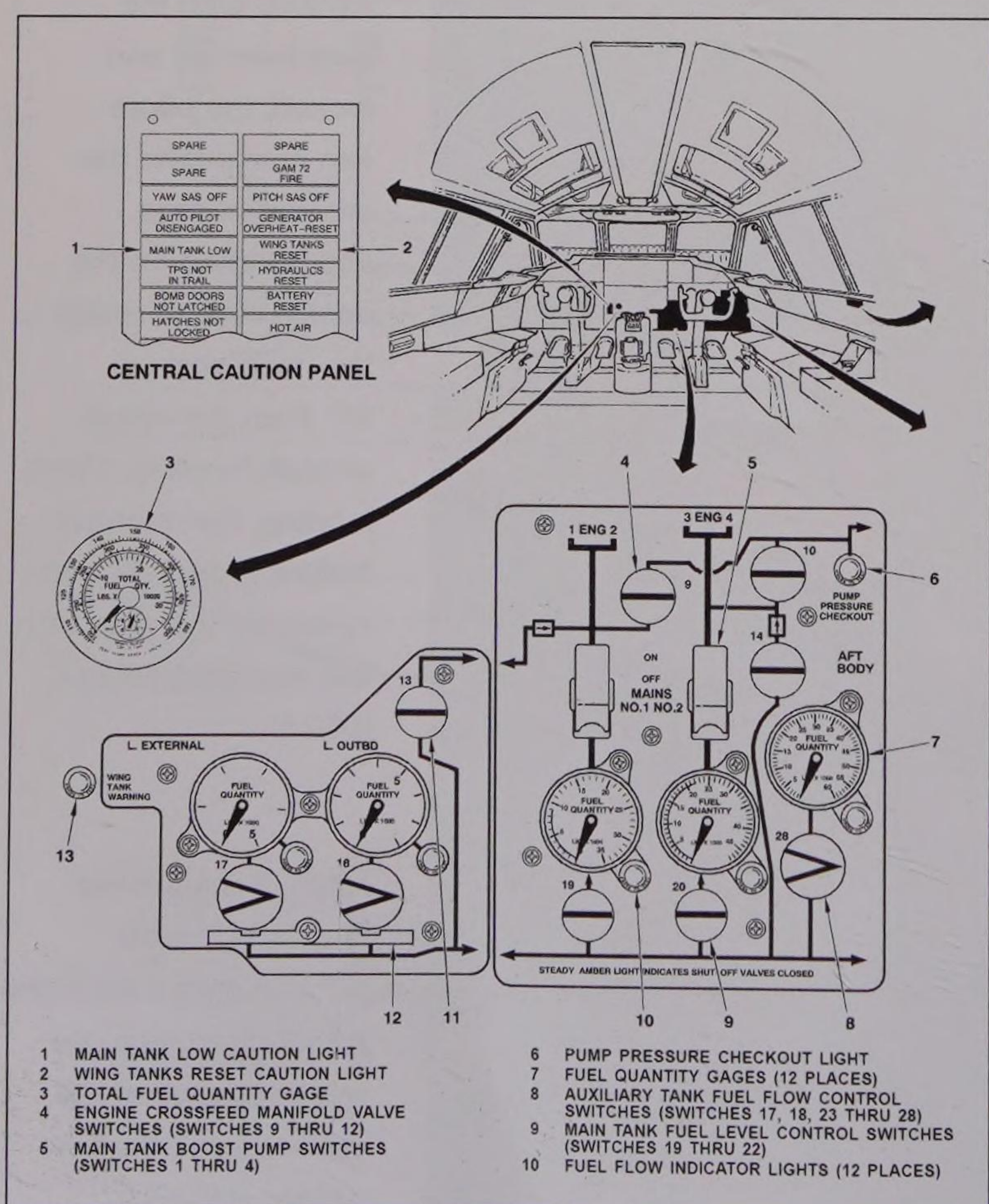
ABOVE With the gear lowered and locked, the pilots can manipulate the crosswind crab control knob on the centre aisle to rotate the main gear up 55° from the actual aircraft heading. Upon landing, the centring button is depressed to re-centre the gear with the aircraft fuselage. (USAF)

LEFT A maintainer installs a freshly packed drag parachute whilst straddling the rearmost part of the tail section, aft of the rudder. (USAF)



ABOVE AND RIGHT The B-52's fuel system schematic shows main tank fuel flow lines in red, while auxiliary lines (coming from the external tanks) are highlighted in blue. The B-52H can carry a total useable internal fuel load of 312,197lb. (USAF)

BELOW It is the co-pilot's responsibility to monitor fuel consumption and transfer fuel at various phases of the mission in order to keep the aircraft balanced. For example, the B-52 must be within very particular CG limits in order to launch (or jettison) the wing-mounted **CALCMs**. (USAF)



main fuel manifold. No1 main tank feeds engines 1 and 2, No2 main feeds engines 3 and 4, No3 feeds engines 5 and 6 and No4 feeds engines 7 and 8. As well as these four main tanks, there are 'auxiliary tanks' that pressurise the main manifold and comprise two external non-jettisonable tanks located outboard of engines 1 and 8, two outboard integral wing tanks, an integral centre wing tank, and three body tanks. The external tanks have a total capacity of 4,550lb and also serve the purpose of reducing wing flutter – in fact, the B-52H is speed limited when the external tanks are empty.

JP-8 fuel is usually used, and is readily identifiable by the excessive smoke that it produces. Whilst this visual characteristic is undesirable, it is not in itself a problem. However, since JP-8 offers slow ignition and slow engine acceleration during engine start when the ambient temperature is below 30°F, JP-4 fuel is instead used to fill the mid-body and external fuel tanks whenever such conditions exist.

Fuel totals (useable fuel) in gallons

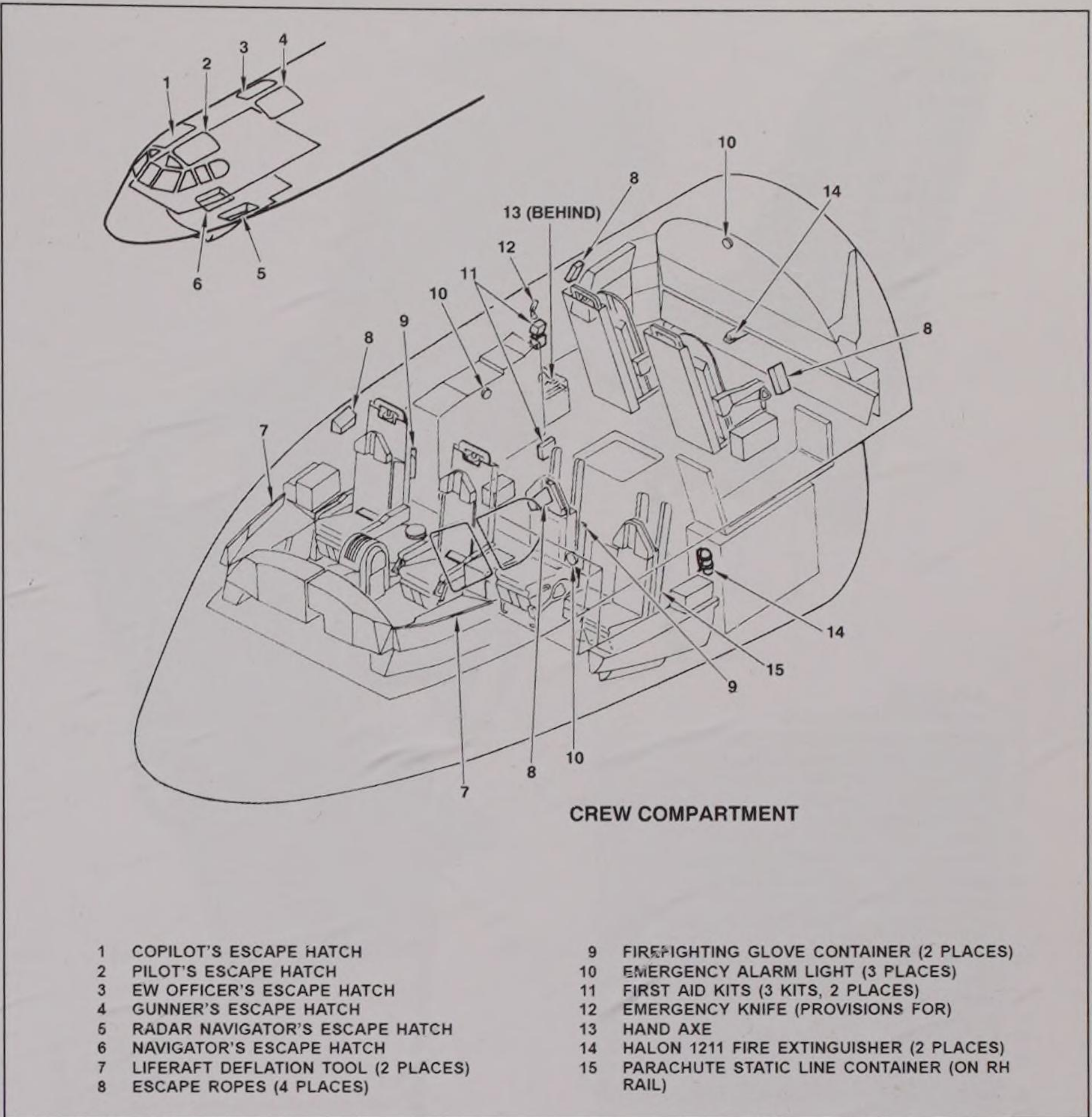
No1, No2, No3 and No4 main	152,204
Mains and mid-body	198,614
Mains, mid-body, forward body and aft body	267,125
Mains, all body, outboard wing and centre wing	303,097
All tanks	312,197

Emergency and escape systems

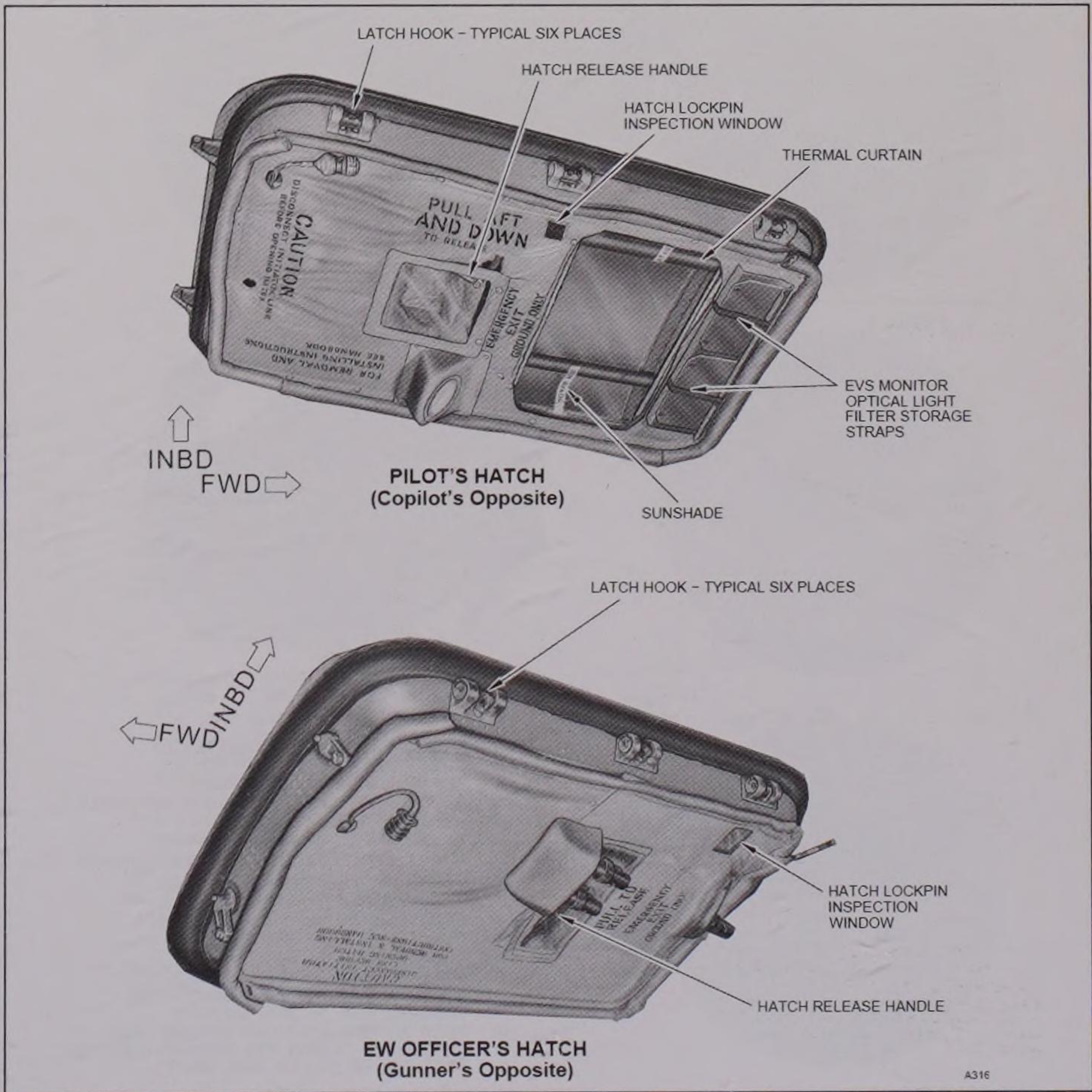
An escape hatch is located at each crew station that is equipped with an ejection seat, making six escape hatches in all: hatches 1 and 2 for the pilot and co-pilot, hatches 3 and 4 for the EWO and a spare crew member, and hatches 5 and 6 for the navigators.

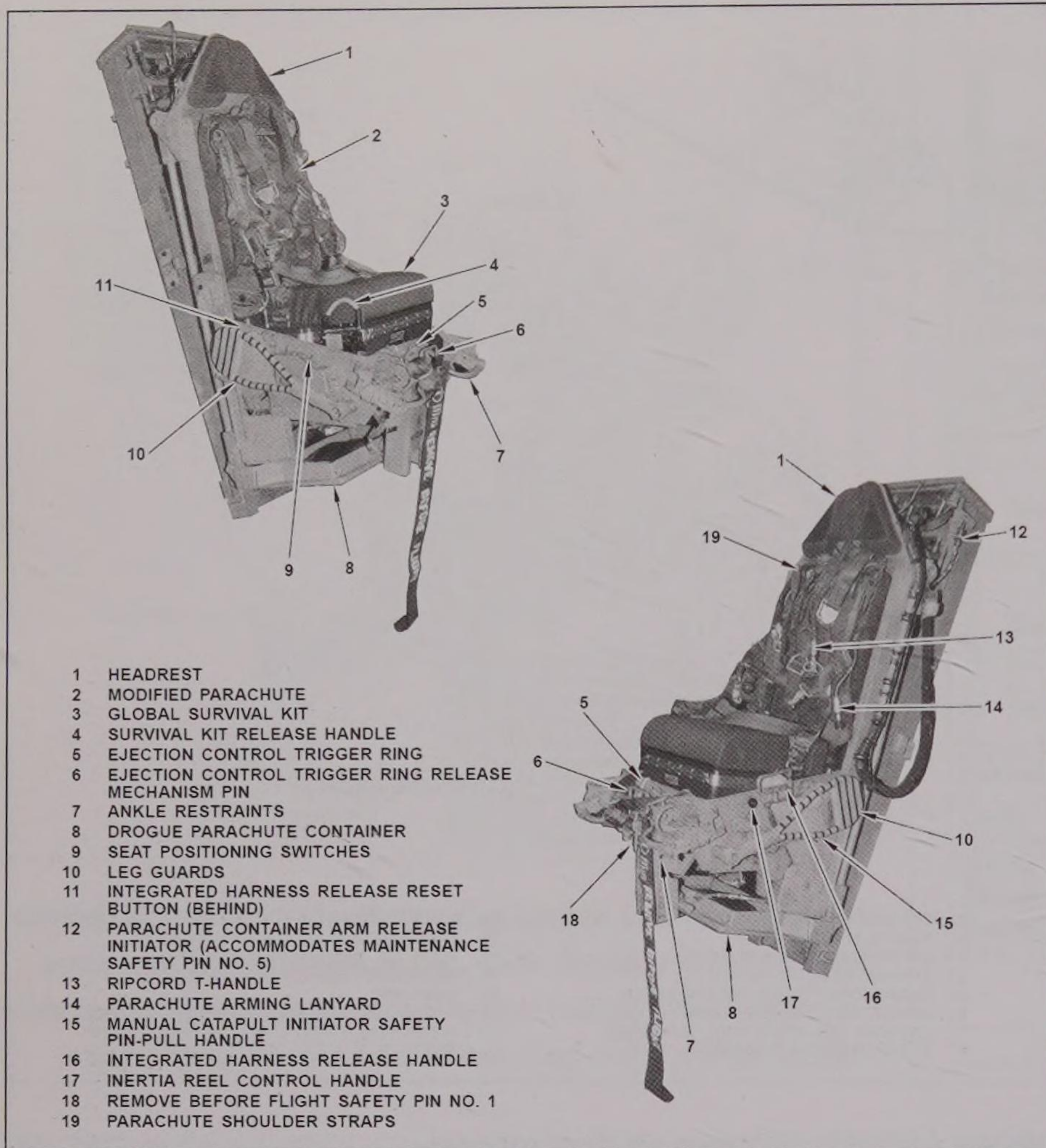
The hatches are of metal construction and are jettisoned to allow the ejection seat to fire out of the aircraft during an emergency. Only the pilots' hatches have windows; these provide side vision when the aircraft is banked and improve upwards vision during air refuelling.

The navigators' aft upward escape hatches (3 and 4) and the downward escape hatches (5 and 6) are equipped with aerodynamic hatch



ABOVE AND BELOW Upon ejection, escape hatches above (and, in the case of the navigators, below) must first be jettisoned. (USAF)



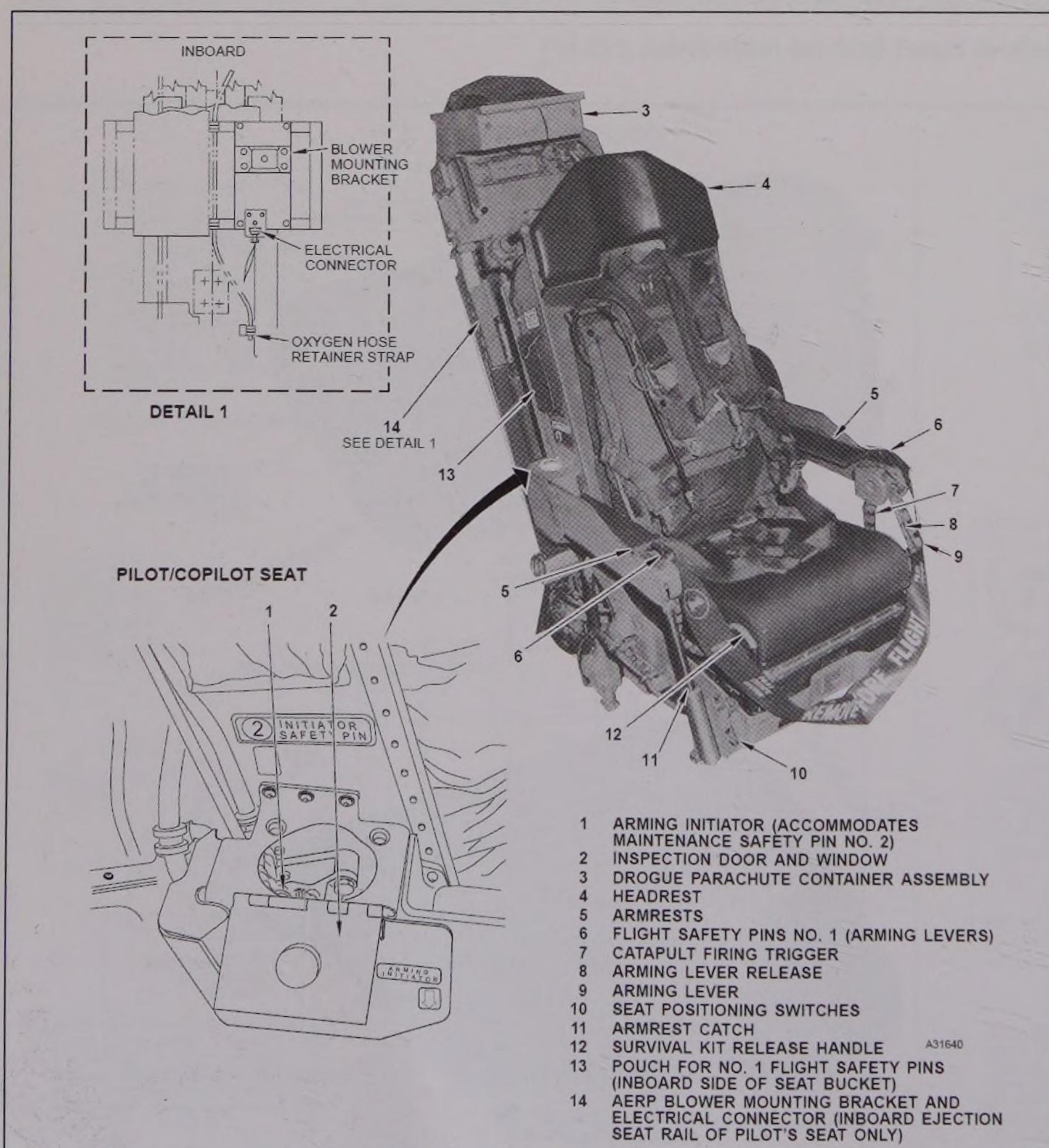


LEFT, BELOW AND OPPOSITE PAGE Ejection seats are provided for the five main crew members (a sixth seat remains from the days when an aerial gunner was carried). Of these, two seats fire downwards (left) and the remaining four fire upwards (below and opposite). The two seat types are largely similar in functionality. All six ejections seats are activated by squeezing the arming lever and rotating it forward and up, then squeezing the firing trigger (opposite below). (USAF)

'lifters' that pop up into the slipstream when the hatch is unlocked during the automatic ejection sequence. When one crew member ejects, the lifters on all four hatches are activated. The hatches may also be released manually for use in emergency ground exit or entrance through the use of hatch release handles, painted yellow-orange, located on the inside of all four upper hatches. For the navigators on the lower deck, a ground emergency egress handle unlocks the escape hatches (5 and 6) below them. Ground personnel may use flush-mounted external hatch release handles to release the hatches in the event of an emergency.

An aft equipment compartment hatch provides an escape route for additional aircrew not seated in an ejection seat. This hatch hinges at the forward end and ordinarily serves as an access door for the aft equipment compartment. It features a yellow jettison handle that is pulled to jettison it into the slipstream, allowing the crew to parachute to safety. When bailout conditions are unfavourable or when the aircraft is ditched, three crash landing and ditching 'hammocks' are provided on the lower deck.

The aircraft's six ejection seats are simple to use and fully automated, and may be used at speeds above 100kt and altitudes above 100ft. Operation of the upward-firing seats of the pilots and navigators automatically result in stowing of the control column, jettisoning of the hatch, ejection of the seat, deployment of a drogue parachute and the release of the occupant from the seat so that an automatic parachute-opening device can deploy their main parachute. The same capabilities are provided for the downward-ejecting seats of the EWO and spare crew member. The ejection seats are

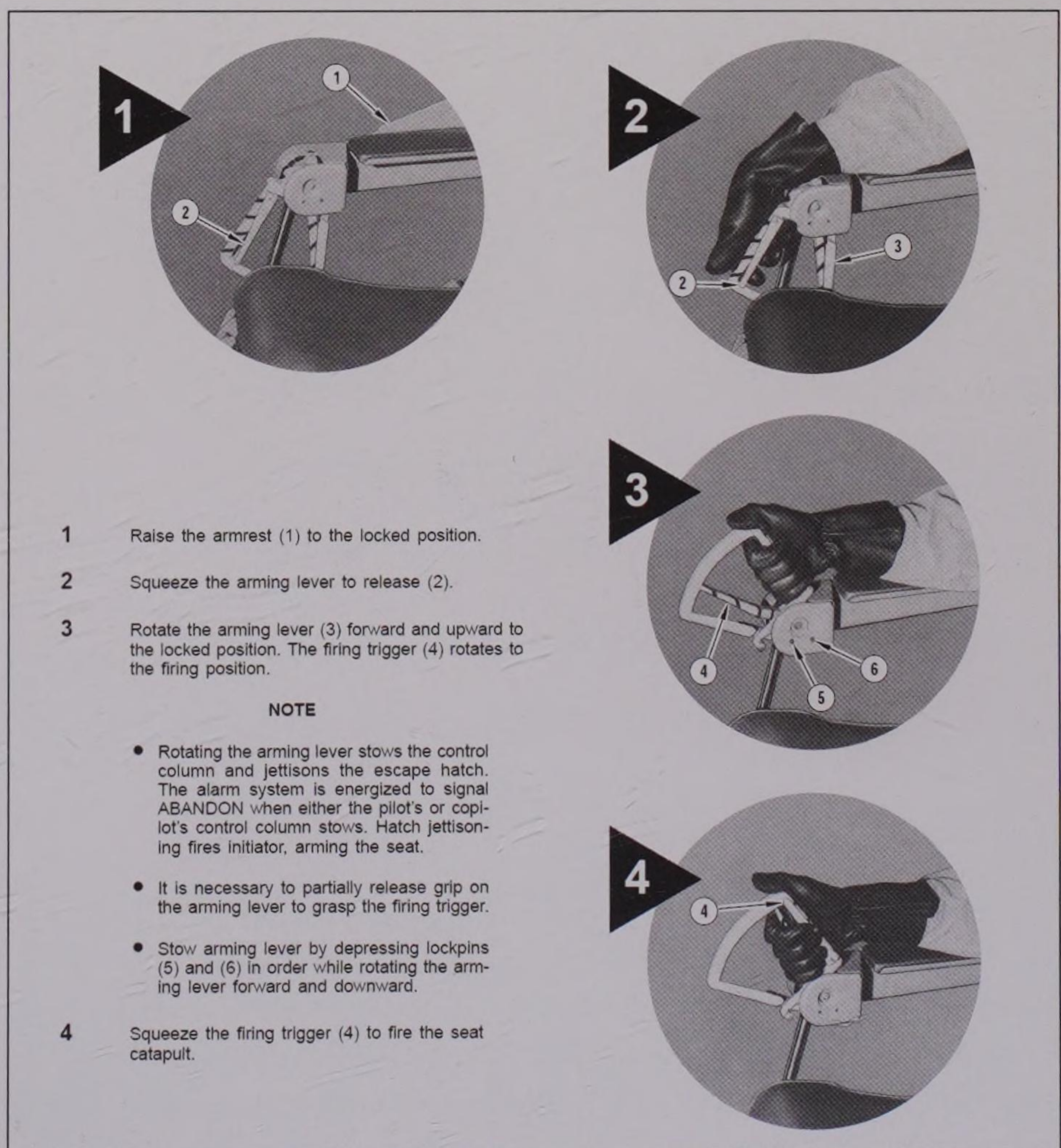
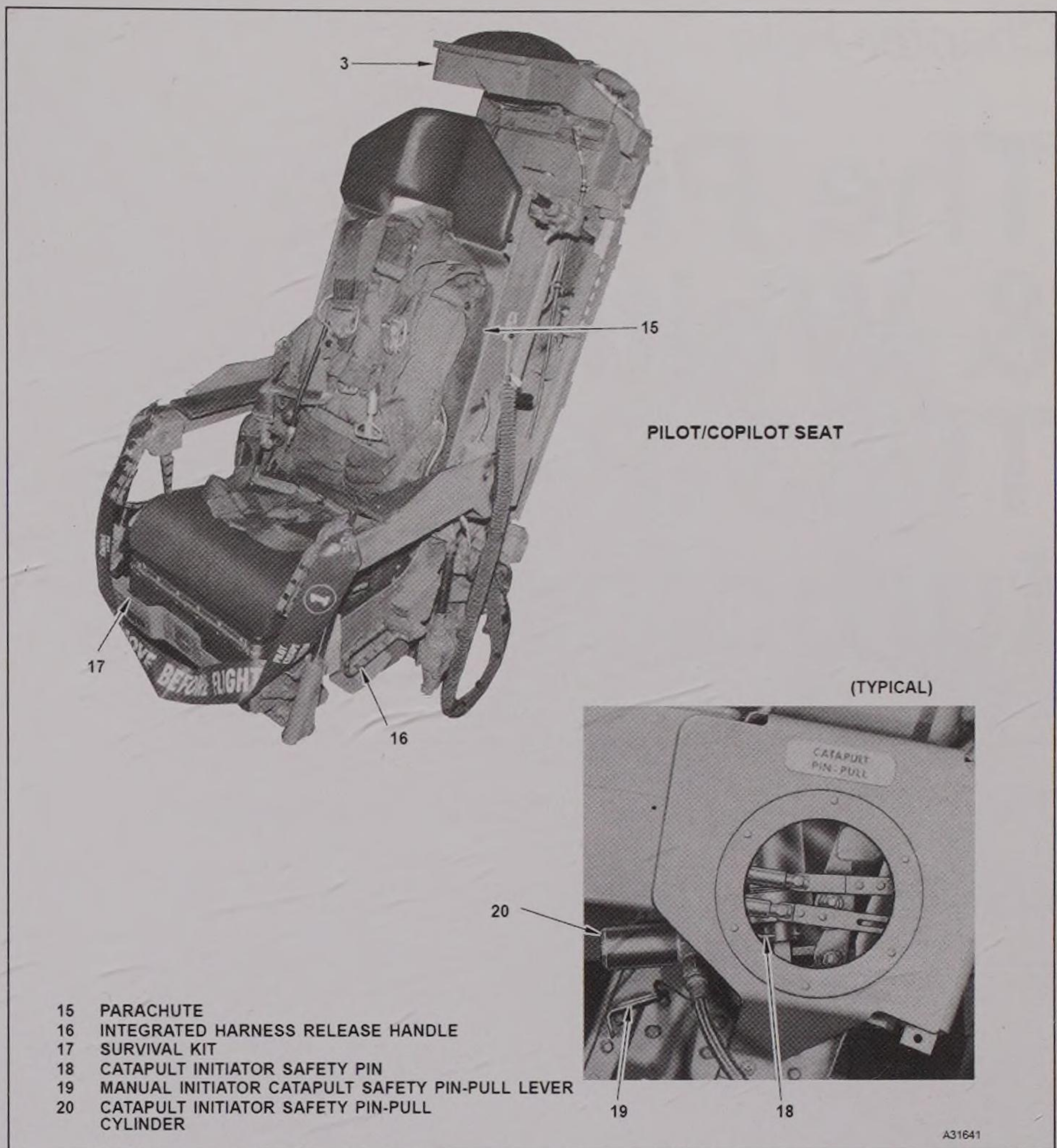


qualified for the 5th to 95th percentile of the male population.

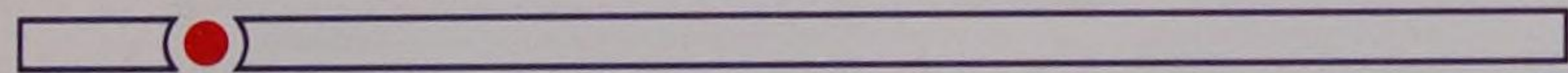
Each seat is equipped with folding armrests in which arming levers are installed (one per armrest). Pulling either lever will lock the inertia reel, stow the control column (in the case of the pilots' seats), jettison the hatch, unlatch the seat drogue parachute arms, and arm the seat for ejection. A catapult then ejects the seat from the aircraft when the trigger inside either arming lever is squeezed. Once the catapult has fired, a drogue deploys to positively separate the seat from the occupant once the seat has left the rails.

The navigators' downward-firing seats will automatically stow the writing table, jettison the hatch and fire the catapult to eject the seat from the aircraft. The drogue then deploys to achieve man-seat separation in the same way as the upward-firing seats. Leg restraints are provided to prevent flailing injuries in the windblast following ejection. So too is a 'man-seat separator', which consists of two straps behind the navigator that are pulled taut 0.3 seconds after ejection. In effect, the straps 'kick' the navigator out of the seat.

All seats are equipped with a type BA-27A automatic parachute, developed specifically for use in the B-52. The parachute features a fast-opening C-9 canopy that offers improved low-level escape capability. It also features an 'FXC model 11,000 ballistic automatic parachute opening release', which incorporates a delay cartridge that automatically opens the parachute pack 0.75 seconds after man-seat separation. A 'bailout oxygen bottle' is attached to the inside of the parachute pack and the CNU-129/P survival kit, providing breathing air to the ejectee automatically. Meanwhile, the parachute harness worn by the crew member is equipped with a universal water-activated release system (UWARS); this automatically disconnects the two parachute risers within 2.5 seconds of immersion in sea water. UWARS reduces the chances of the ejectee becoming entangled in the risers, prevents them from being dragged through the sea when surface winds continue to inflate the parachute following landing, and mitigate against the possibility of the parachute dragging the crew member beneath the water should it be caught by underwater currents.



The Pratt & Whitney TF33-P-3 turbofan



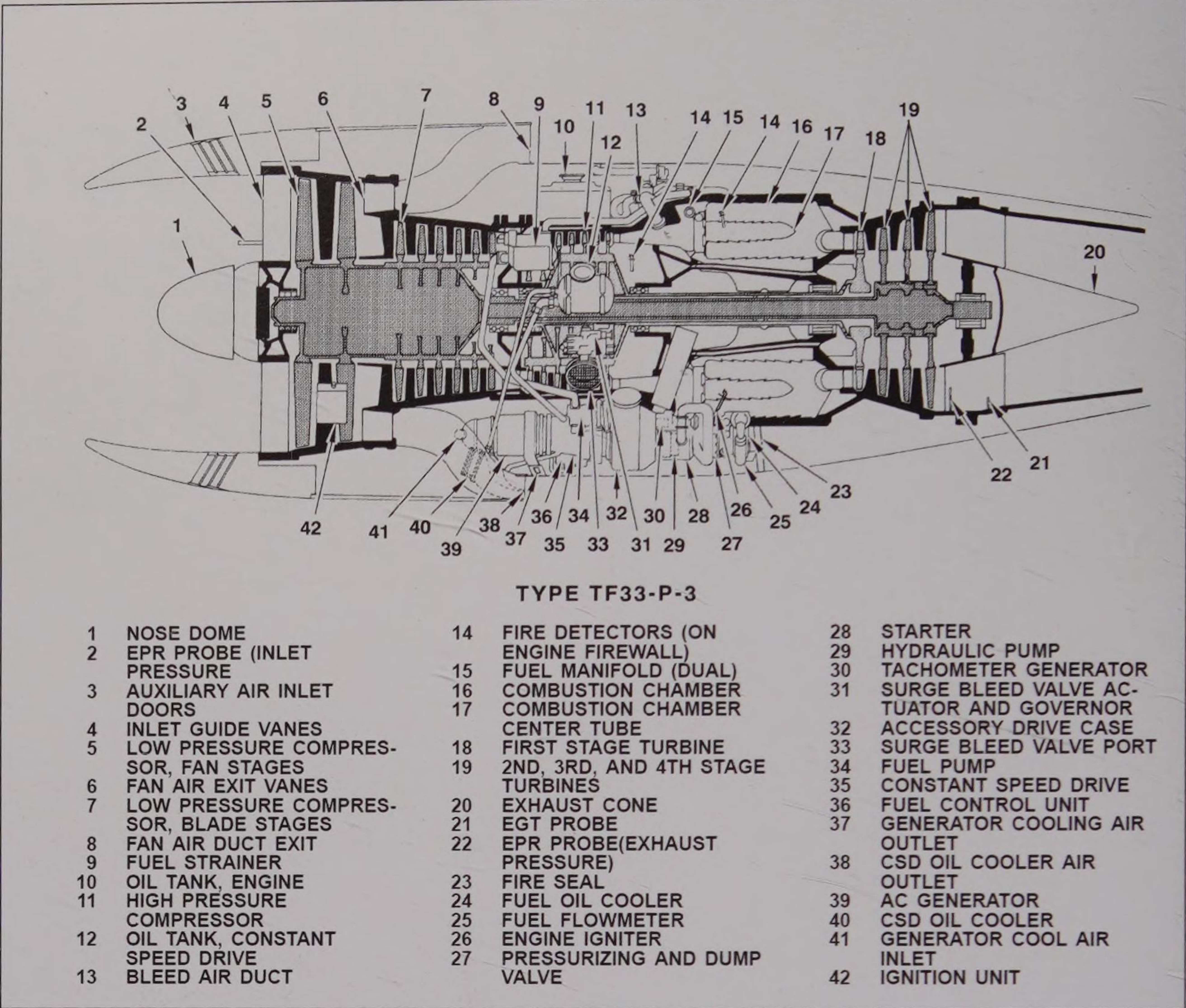
The P&W TF33-P-3 engine is installed only on the production-specification B-52H; all previous variants of the Stratofortress were equipped with the J57 turbojet. The TF33 series, known as the JT3D in its civilian guise, also features on 135 of the US Air Force's KC-135E 'Stratotanker' (TF33-P-5) and powered the now-retired C-141 'Starlifter' (TF33-P-7). Whilst reliability problems were encountered when the TF33 first entered service, these had been largely resolved by 1964. The engine produces 17,000lb of thrust.

OPPOSITE Streaming exhaust smoke during water-injected take-off, three turbojet B-52G Stratofortresses take to the skies during an operational readiness inspection by the Strategic Air Command Inspector General Team. Soot-laden skies might forever be associated with the BUFF, but today's H-model is a far cleaner beast. (USAF)





RIGHT A side cutaway view of the TF33-P-3 – the variant of the TF33 that powers the B-52H – reveals the low-pressure and high-pressure compressor sections at the front, and the turbine section at the rear. (USAF)



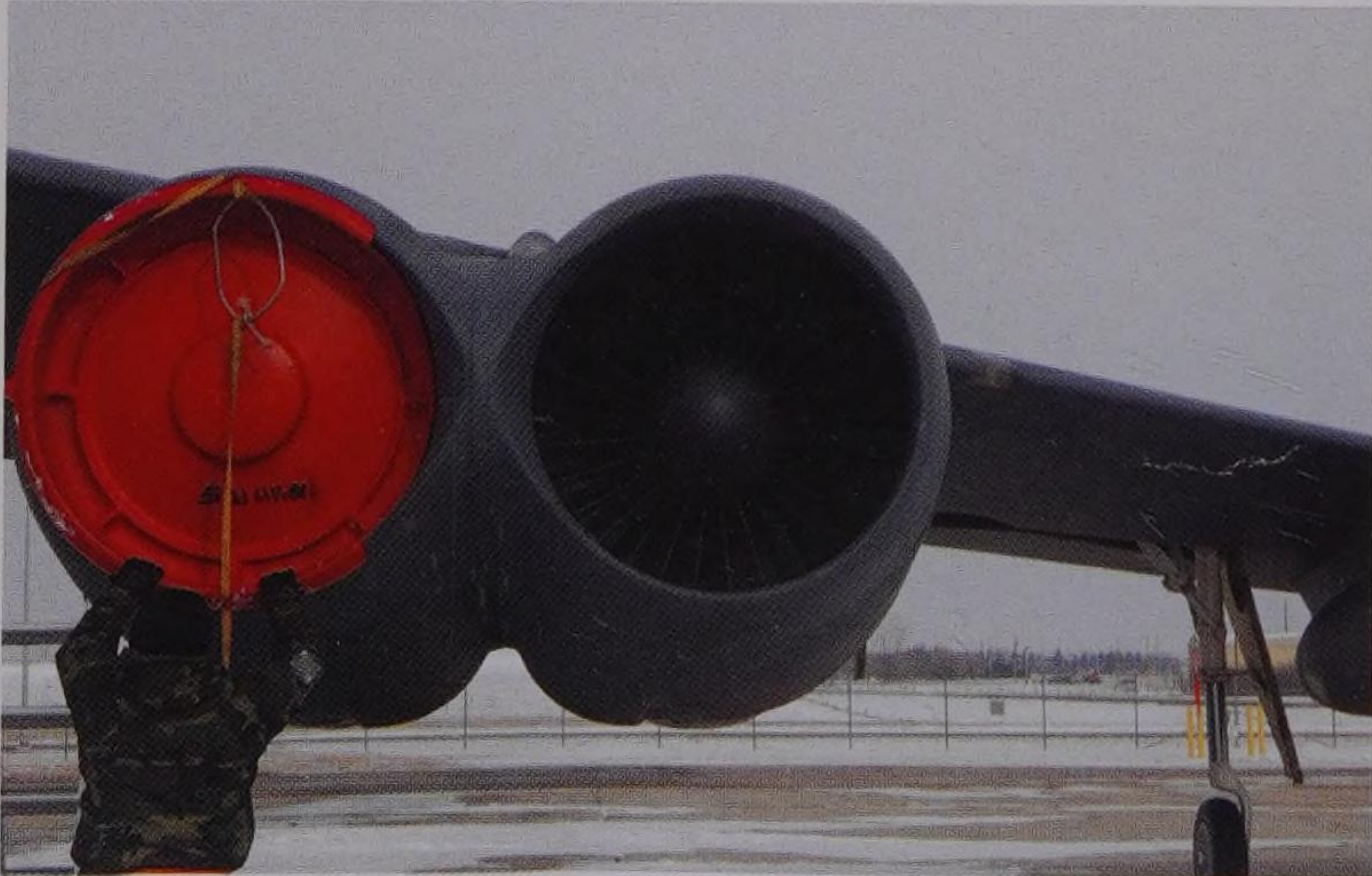
BELOW The podded mounting of the two TF33s, of which there are eight in total, is clear in this image. The engine nacelle to the left has its protective cover in place to prevent foreign objects from entering the intake. (USAF)

Eight P-3s are installed on each B-52. The engine features a low-pressure compressor made up of a ‘fan assembly’ and a compressor. The fan assembly is the name given to the first and second stage rotor blades, as these are longer than the remaining stages of the compressor.

The engines are installed in pairs in four nacelles – two per wing – that are also referred to as ‘nacelle pods’. These pods incorporate diametrically shaped exhaust bypass air ducts

around the outboard and inboard sides of each engine. Each nacelle pod has a cowling that has quick-release latches to provide maintenance access to the engines.

BELOW The frontal surface area of the TF33 is surprisingly small, as demonstrated by this engine specialist sitting inside the nacelle. Despite this, each engine can produce up to 17,000lb of thrust on take-off. (USAF)





LEFT Servicing of the TF33 is relatively straightforward since access to the engine is granted by means of nacelle doors that can be opened either fully, or partially. The TF33 has lasted the test of time: in the upper photo, maintainers perform checks on a B-52G Stratofortress aircraft during Operation Desert Shield in 1991; in the lower photo, a TF-33 flight test mechanic works on the engine at Tinker AFB in the early 1960s. (USAF)

Bypass air and cooling

Each pod has a 'nose cowl' for each engine, left and right upper and lower 'wrap cowls', and left and right upper and lower 'aft-body cowls'. The wrap cowls cover the fan case and a portion of the turbofan exit ducts. Airflow from the engine fan exit ducts is discharged axially over the aft-body cowl, which covers the engine-mounted accessories and the remainder of the engine from the fan bypass duct exit to the aft end of the tail pipe.

Meanwhile, the nose cowl acts as the air inlet to the engine. It is characterised by eight auxiliary air inlet doors that allow a sufficient volume of air to enter the engine during ground operation and take-off. These doors are spring-loaded closed, opening only when differential pressure between the inside and outside is created. The doors are closed for most of the B-52's flight envelope (this is dependent on Mach number, engine thrust setting and aircraft angle of attack), opening mostly during ground and take-off operations.

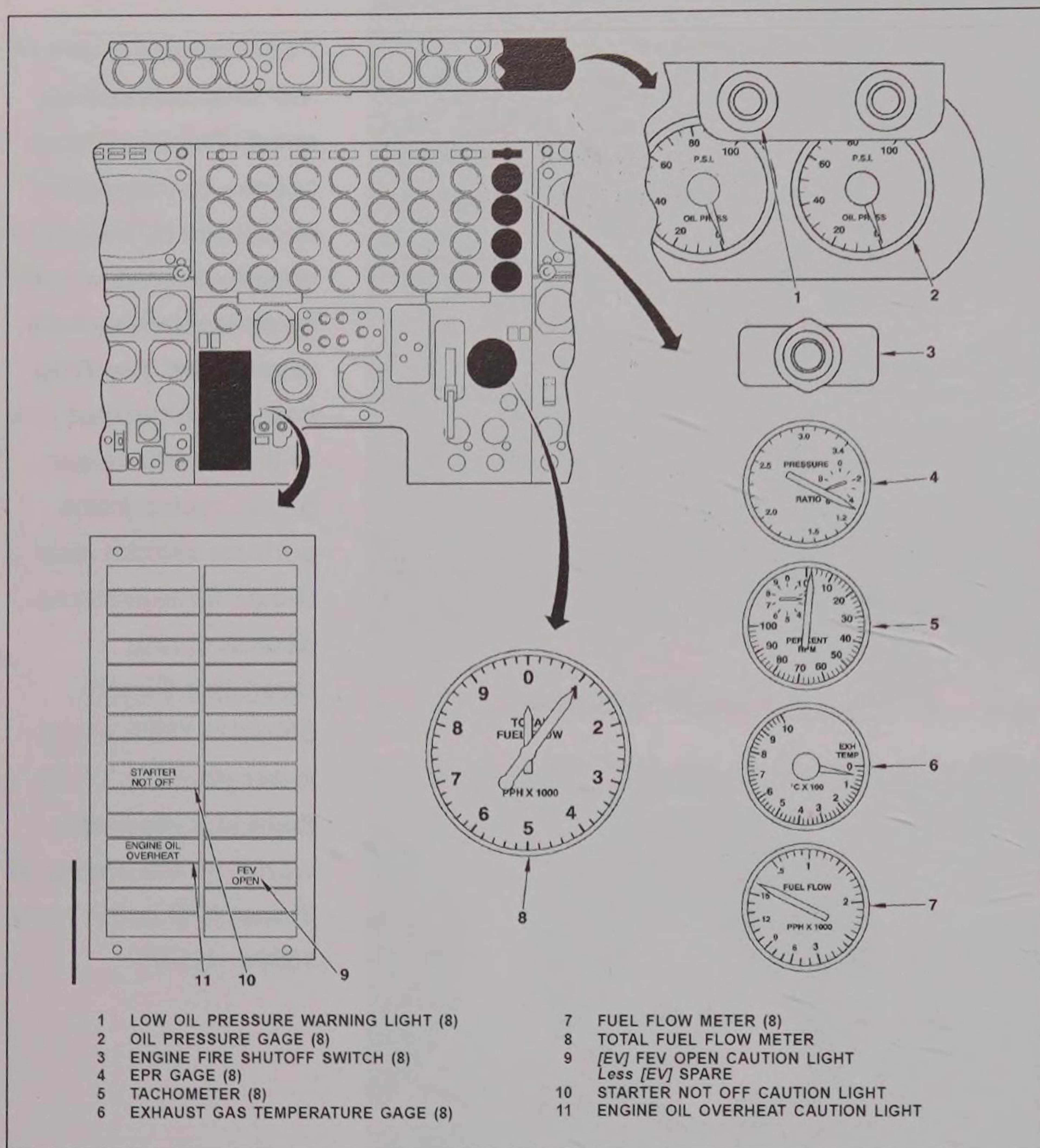
An electrically controlled air-drive starter and a constant speed hydraulic drive (CSD) are installed on the lower side of all eight engines. Each CSD has its own air-oil cooler located aft of the generator – engine fan air passes over the cooler before being routed outside the nacelle pod. Fan air is also used to cool the generators before being routed overboard via the aft-body cowl. The installation of an engine-driven, variable-delivery hydraulic pump



to the lower right side of engines 1, 3, 4, 5, 6 and 7 differentiates them from engines 2 and 8. Likewise, a 120KVA generator is attached to engines 1, 3, 5 and 7, but not engines 2, 4, 5 and 8.

All of the engine-mounted accessories are driven from a gearbox directly connected to the main shaft connecting the first stage turbine to the high-pressure compressor, while rpm for the 120KVA generator is maintained by the constant speed hydraulic drive installed on the same engine. The accessory gearbox also powers the two-stage fuel pump, hydro-mechanical fuel control unit, tachometer generator and oil pressure transmitter.

Bleed air from the 16th stage compressor is used for pressurisation of the CSDs and their associated oil tanks, while turbofan discharge air is used to cool the generator and the CSDs' oil tanks. Ninth stage low compressor pressure is used for anti-icing of engine nacelle cowls, inlet guide vanes, nose domes, and inlet pitot tubes for the engine pressure ratio transducers.



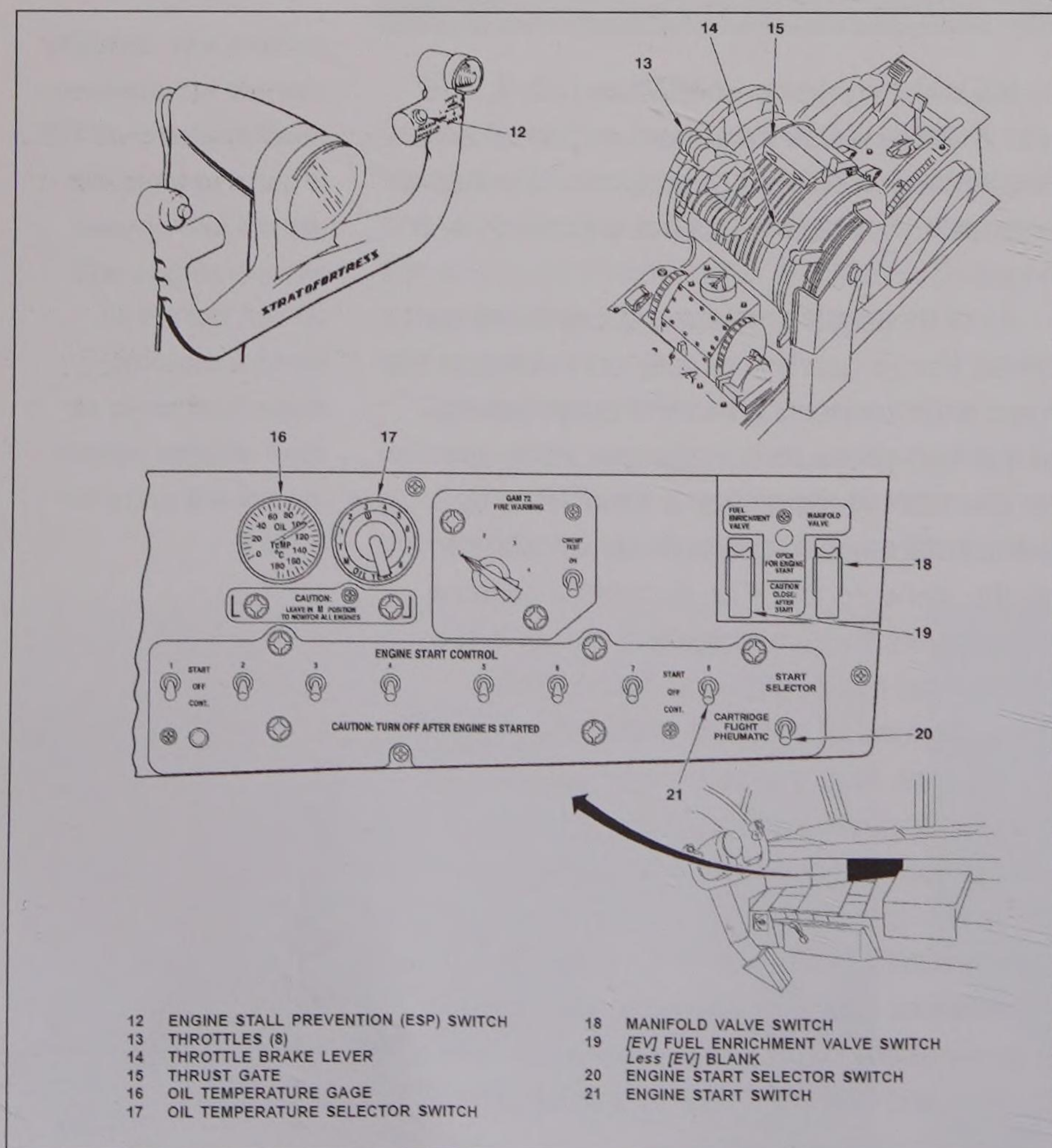
LEFT AND BELOW Eight engines equate to an impressive number of dials and displays in the B-52's cockpit. The front console is dominated by these, while the centre aisle boasts a hefty throttle quadrant with which to control the engines either individually, in multiples of two or more, or all at once. (USAF)

Fuel control, throttles and oil supply

Each TF33-P-3 engine has a JFC 25-14 fuel control unit (FCU). It is a hydro-mechanical unit that coaxes optimum performance from the engine at any thrust setting. Variations in inlet temperature, altitude or airspeed do not therefore require the pilots to fine-tune the throttle lever position for each engine. The JFC 25-14 has a metering and a computing system, the former of which sets the rate of fuel flow to be applied to the engine burners according to throttle setting, while the latter ensures that the engine operating limits are not exceeded. Fuel is supplied from the fuel tanks, via the fuel supply system, to fuel control units; these then meter fuel to each engine.

Eight throttles, located on the aisle stand in the cockpit, provide engine thrust control by positioning a throttle valve in each FCU, while an electrically operated firewall fuel shut-off valve controls the fuel entering the engine. On engine start, moving the throttles over a mechanical stop on the throttle quadrant automatically energises these valves. In doing so, the two-stage, engine-driven boost fuel pumps pressurise the fuel flow. A bypass valve allows fuel to bypass the first pump stage in the event of failure, proceeding directly to the second stage and then on to the FCU.

The throttle quadrant is marked with the following annotations: 'closed - idle - open'. In the 'closed' position, essential DC power closes the firewall fuel shut-off valves. Advancing the throttles beyond this position provides power to open the firewall fuel shut-off valves, but this is overridden if either pilot has pulled the manual fire shut-off toggle switches. Essential DC power is supplied to the engine ignition circuit for starting when



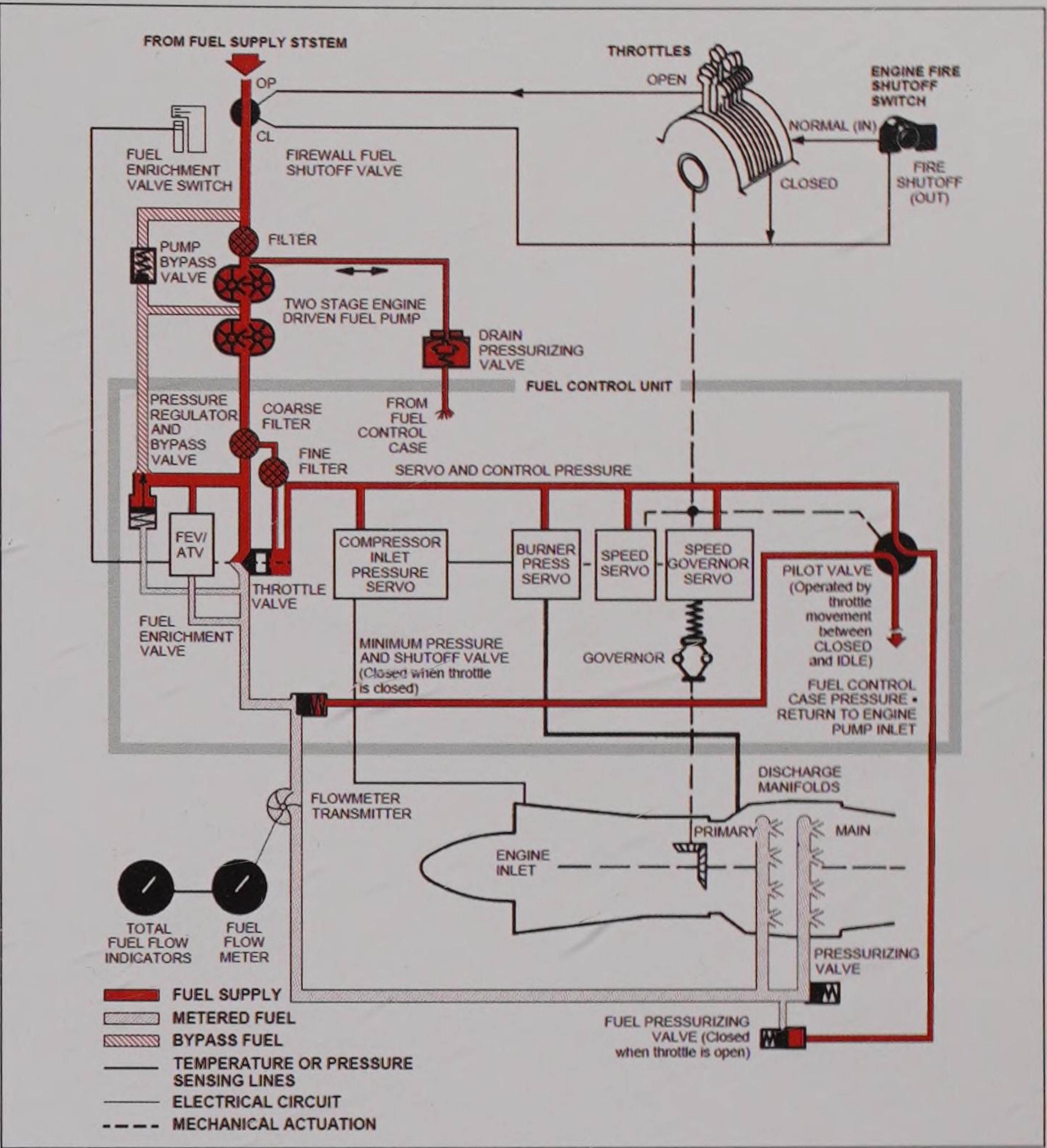
RIGHT This fuel supply schematic charts the journey that the fuel takes, courtesy of the JFC 25-14 fuel-metering and computing system. This hydromechanical device sets the rate of fuel flow to each engine based on the position of the respective throttle lever. (USAF)

the engine starter switch is in the ‘start’ position. With the throttles advanced in the region of 18° beyond ‘closed’, the fuel control sequencing valves move to provide fuel pressure that, in turn, closes a fuel dump valve. Next, fuel is pressurised and metered to the primary manifold of each engine.

A fuel enrichment system allows cold-soaked engines to be ground started at low temperatures (below 0°C) or air started above 15,000ft. It is used when the engines are being fed JP-5, JP-8 or JET A/A1 fuels, but is not required when JP-4 fuel is in use. It is composed of two major components: a fuel enrichment valve (FEV) and an auxiliary throttle valve (ATV). The co-pilot sets the FEV switch to ‘open’, which causes the FEV to supply fuel under pressure to the ATV. The ATV, which is mechanically connected to the throttle levers, opens to increase fuel flow once the throttle lever is lifted beyond the ‘closed’ detent. Once engine rpm has increased, the ATV closes.

Six of the eight throttle levers (1, 2, 3, 6, 7 and 8) have a different height from the lever adjacent to them. They are also kinked as they exit the throttle quadrant so as to separate them laterally as well as vertically. This helps the pilots select each throttle individually, which is most important during ground operations where tight turns may need to be accomplished. The two centre throttle levers – 4 and 5 – are the same height and rise vertically from the quadrant. Smaller throttle levers are connected to each large throttle lever to allow either pilot to manipulate all eight throttles simultaneously, as is typical during take-off, normal flight operations and landing. A mechanical detent prevents any throttle lever from being retarded into the ‘closed’ position unless it is first raised by one quarter of an inch.

Each engine is equipped with an integral oil system that supplies oil pressurised at up to 5psi above atmospheric pressure to an



BELOW Throttle position chart, indicating the activation of the firewall fuel shut-off valve, engine ignition, fuel pressurisation and fuel dump valve, and the warning horn, based on throttle position. The warning horn sounds when conditions exist that might suggest the pilots are attempting to land without first having lowered the undercarriage. (USAF)

THROTTLES POSITION	PERCENT RPM	FIREWALL FUEL SHUTOFF VALVE POSITION	IGNITION	FUEL PRESSURIZING AND DUMP VALVE	WARNING HORN
CLOSED	0%	CLOSED	Not Available	Open	
Advanced		Open unless engine fire shutoff switch is pulled	Available when throttle is advanced from CLOSED with engine starter switch in START.		
18° approx	(Starting)			Closed. Metered fuel under pressure is supplied to primary manifold.	
IDLE					Energized if throttle is retarded when landing gear is not down and locked.
45° approx.	75% approx.				Energized if aircraft is on the ground and the flaps are not fully extended.
Cruise	84 to 94%				
OPEN	106.7% max.				



LEFT AND BELOW Sooty take-offs, like the one being flown by this J57-powered B-52G (left), were the by-product of water injection, where unburned fuel would carbonise in the hot exhaust. Contrast this to the much less sooty, but still somewhat smoky, take-off of the TF33-equipped B-52H (below). (USAF)

engine-driven oil pressure pump. The oil is drawn from an oil tank with a minimum usable capacity of 7.10 gallons and a total capacity of 10.23 gallons. When the engines increase rpm to beyond idle, the pump regulates a constant supply of 80lb of oil per minute at 45–50psi. The oil lubricates the TF33's bearings and accessory drives, while a scavenge pump returns excess oil to the oil tank for reuse.

The TF33 is equipped with an oil temperature probe that senses temperatures in a range from -54° to 176°C . Oil temperature is controlled by a thermostatic valve integral to the fuel-oil cooler. Made from a cylindrical chamber, the cooler flows fuel between the chamber and a cylindrical jacket to maintain an oil temperature between 40° and 120°C . The co-pilot monitors the oil temperature of each individual engine via a selector switch on the cockpit side panel.





TF33-P-3 operation

The TF33's starter turbine may utilise either low-pressure bleed air provided by a ground 'start cart' or source bleed air from any other engine that is already operating. Alternatively, high-pressure gas generated by burning a solid propellant cartridge – colloquially known as a 'shotgun' start – may be used when limited or no ground support equipment is available. The main difference between bleed air and shotgun starts is the temperature and pressure of the two gases. Bleed air enters the starter turbine at a temperature of 500°F or lower, but the solid propellant creates gas at a temperature in excess of 2,100°F.

Each starter is geared to the engine's high-pressure compressor and comprises a turbine, gear train and 'overrunning' clutch. As engine rpm exceeds that of the starter turbine, the clutch releases to prevent the starter turbine from over-speeding, while a centrifugal switch monitors rpm and shuts off the starter air supply once the target rpm is reached.

A dual ignition system uses DC power for starting and AC power to prevent flameout. Spark igniters located in the combustion chambers of each engine are responsible for actually starting the ignition process, and are controlled by eight starter switches, a start selector switch and the throttles.

While the TF33 is not equipped with an engine fire extinguishing system it does have a



fire detection system, consisting of separate fire detection circuitry for each engine. Thermally actuated fire detectors are wired in parallel, and provide fire warning signals through a light on the pilots' instrument panel. There are a total of eight of these red engine-fire warning lights, each representing one engine. The fire warning lights illuminate when a fire detector unit on the affected engine is thermally triggered.

Each light is integral to a two-position, pull-push fire shut-off switch that is T-shaped. Pulling a switch to the 'fire shut-off' position closes the engine firewall fuel shut-off valve for the corresponding engine. When the 1, 3, 4, 5, 6 or 7 switches are pulled the respective engine firewall hydraulic shut-off valve is also closed. Similarly, when handles 1, 3, 5 or 7 are pulled the respective generator control relay is tripped to de-energise the generator.

Conversely, pushing a fire shut-off switch back into the 'normal' position restores the engine

LEFT AND ABOVE
Two options are available for starting the first TF33 on engine start: the use of compressed air [left] or start cartridges. The former is cleaner, but requires a start cart, while the latter creates clouds of billowing smoke but does not require specialist ground equipment, since a stowage rack of eight starter cartridges is provided in the aft wheel well. Whilst [above] may look like a starter cartridge has been fired, this is in fact a cold-weather start (-25°C) using compressed air at Minot AFB, North Dakota. The TF33 is currently being tested with a synthetic fuel with a view to replacing JP8. (USAF)

RIGHT AND BELOW

Accumulated dirt and grime needs to be cleaned from the engine pod cowls even in times of war.

In this sequence of images, airmen wash the inside of B-52 engine cowlings during Operation Iraqi Freedom in 2003. About a dozen maintainers are required to clean the BUFF as part of the

Phase inspection after every 300 hours of flying, and this is one of the first tasks performed in what is called the 'contingency phase' of maintenance.

With panels inspected for shape, deformations, cracks or other irregularities, problematic panels are sent to the metal shop to be repaired or refabricated. (USAF)

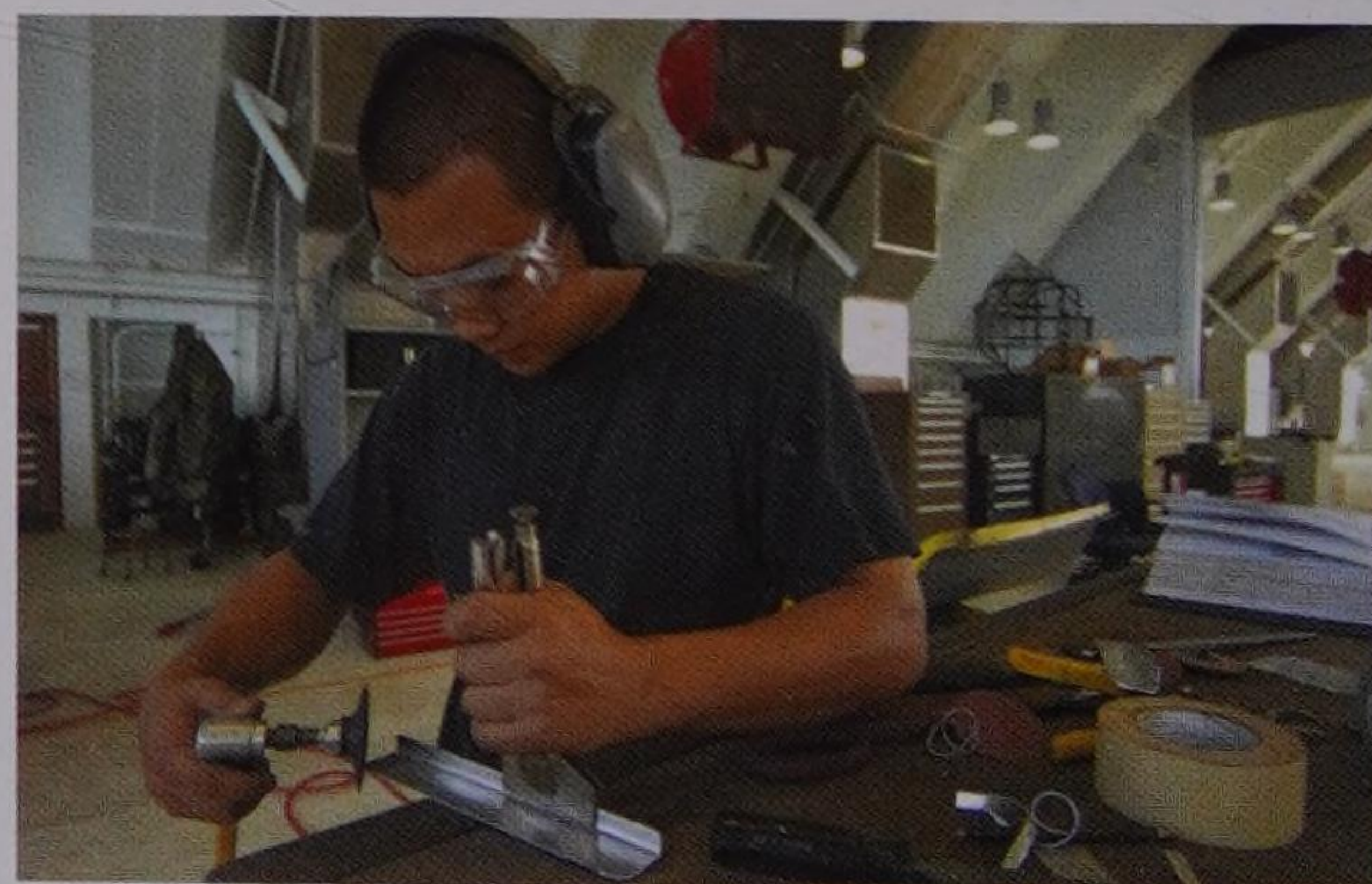


firewall fuel shut-off valve to normal control by means of the throttle. Returning the fire shut-off switch to the 'normal' position for engines 1, 3, 4, 5, 6 or 7 will open the engine firewall hydraulic shut-off valve, but will not restore the generator; this must be accomplished manually.

When the aircraft is on the ground, air entering the inlet around the cowl lip separates and produces areas of low pressure across the compressor face. When wind blows across the inlet lip the effect is exacerbated. To deal with this phenomenon, an engine stall prevention system controls compressor surge bleed valves to prevent the compressor from stalling. It does so via auxiliary air inlet doors incorporated in the

cowl. Opening the doors increases the inlet area while also minimising the pressure distortion. Solenoid valves, controlled by a single engine stall prevention switch on each pilot's control wheel, open and close the auxiliary inlet doors.

The stall prevention system offers protection up to crosswinds of 10kt, but stronger crosswinds may still cause stalls. Still, the protection that is afforded by this system is sufficient to allow normal ground operations, and the aforementioned distortion lessens dramatically when airspeed increases to beyond 50kt during the take-off roll. The stall prevention system control circuit is de-energised when landing-gear squat switches are tripped as the undercarriage is raised.



RIGHT AND BELOW
With the engine panels removed the engine mechanics are able to service the eight TF-33 engines. In this sequence of images, specialists use a safety wire to secure a quick disconnect line to prevent leaks on a B-52 aircraft, change the anti-ice valve and conduct general inspection and maintenance in accordance with their technical orders.
(USAF)

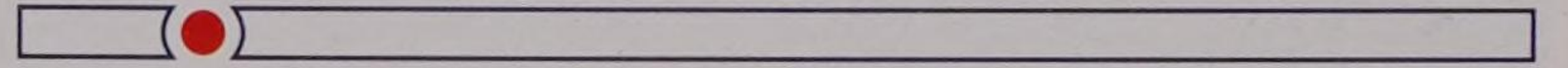






Chapter Five

Flying the Stratofortress: the pilot's view



'Flying the Boeing B-52H

Stratofortress heavy jet bomber is an experience like no other,' says Major (retired) Scott Moore, a 4,000+-hour B-52 co-pilot, aircraft commander, instructor pilot and evaluator pilot. In this chapter, Moore provides a narrative that focuses primarily on the fundamental elements involved in getting the B-52 safely into the air, over the target and back home in one piece.

OPPOSITE The entire crew wait as the pilot in command checks the Form 781 at the aircraft. This form contains a history of the aircraft's maintenance status, to include any aircraft systems that may be problematic or not fully functional. (USAF)



ABOVE While the aircrew create their mission plan, their waiting B-52 must be readied for flight. Here, a B-52H is prepared for fuelling. (USAF)

Mission planning

A typical training flight in the B-52 is a two-day process. Day 1 – mission plan; day 2 – fly the mission, then debrief and critique the flight.

'Mission planning actually starts before mission planning day, with the navigator checking the flying schedule that is published weekly by the Wing schedulers to see where we're going, when we're going there and what we're going to do when we get where we're going.

'For most of the time I flew the B-52, we were also pulling alert approximately once every three weeks for a week at a time. Alert commitments were also factored into the schedule, with flying taking place during the intervening two weeks between alert cycles. Every week the schedulers would publish the next week's flying schedule, listing which crew would fly which airplane, mission times, fuel (and sometimes bomb) loads, low-level routing to fly, tanker(s) to air refuel with, etc. The crew navigator would get his copy of the schedule and start planning a route of flight that would accomplish all the flight's requirements. Actually, a lot of the missions were "canned", meaning that they were already generally planned out and all the navigator had to do was plug in the mission timing from the schedule and maybe adjust a leg of the flight here or there to make timing.

'On the actual mission planning day, the crew would meet in the Bomb Squadron building to put it all together. A crew consisted of the aircraft commander (AC, but called "Pilot" over

the intercom), co-pilot (CP, "Co"), radar navigator (RN, "Radar"), navigator (N, "Nav"), electronic warfare officer (EWO, "E-dub") and a defensive aerial gunner (G, "Guns"). We would, on occasion, be assigned additional crew members to fly with us. Usually these were instructors for any of the crew positions – instructor pilot (IP, "IP"), instructor radar navigator (IRN, "IRN"), instructor electronic warfare officer (IEW, "I E-dub") or instructor gunner (IG, "IG"). Note that an IP could supervise and instruct both an AC and a CP, and an IRN could instruct both an RN and a Nav.

'As the aircraft commander, I would go over the scheduled mission with the rest of the crew, discuss any changes or additions to the schedule and set a crew briefing time. The nav team (RN and N) would then go off on their own and do their own planning, the defence team (EWO and G) would coordinate any special requirements pertaining to them, the co-pilot would work on computing the fuel required for each leg of the flight, the weight and balance data for the aircraft and the take-off and landing data that we would plan to use, while I would complete the flight plan and other paperwork that we had to turn in before we could actually fly. At some point, the pilots and the nav team would meet with personnel from the wing's bomb/nav shop for target study.'

The mission

On fly day, the crew would assemble at the squadron building at the designated show time, usually 2½ hours prior to our scheduled take-off time. I would ensure everyone had the correct flying gear with them (especially in winter, when we had to wear or have heavy winter clothing), all necessary publications and manuals, check the CIF one more time, call Job Control to confirm the tail number, fuel load and parking spot, and generally make sure we were ready to fly. The EWO would go to Tac Comm (Tactical Communications branch) and check out a big flight bag with all the classified communications code books, the KIK-18 code gun (a device used to enter a classified code into the aircraft's transponder) and the DoD-published flight charts, manuals and approach plates.

'Once at the jet, the crew chief and, usually, the deputy crew chief would board the bus and hand me the Form 781. The 781 was a binder that contained all the maintenance forms for the jet. At this point the crew chief would tell me what kind of shape the jet was in and if there were any maintenance issues I needed to be made aware of. I would then open my "Pilot's Abbreviated Flight Crew Checklist" (a 5in x 7½in handbook, each page printed on yellow paper and encased in a protective plastic sleeve and held together by snap rings which contained all the necessary checklists for flying the B-52 and which we used in flight rather than the larger, bulkier "Dash One" pilot's manual) and run the "Before Exterior Inspection" checklist.

'I would brief whichever of the crew chiefs was going to be on the headset and talking to me (called "Ground") about the various items under No2 on the checklist. For the stab trim check, since the pilots can't see the horizontal stabiliser as it moves during the trim check, Ground has to tell me which way it's moving so I can correlate it to my trim switch position and the motion of the trim wheel in the cockpit. For the alarm system check, Ground will confirm that the red "bail out" light in the bomb bay comes on when I flip the switch. I brief Ground to start the start cart and connect external air at the proper time. The start cart is basically a small jet engine in a casing on wheels with a 6in diameter hose running from the jet engine that is used to provide high-velocity air to our jet's engines to spin up the turbines for engine start. It's very noisy, so we don't want it started until we need it.

'At the time I was flying the B-52, both the G and the H model were in service. The two models were similar in almost every respect except for the engines and the tail guns. Thus, instead of printing two separate Dash Ones for each model, which would have been identical for the most part, Boeing chose to print just one Dash One and to annotate any items which were specific to just one of the models, as was the case here. Since I am describing a flight in the B-52H, I will not elaborate on any G-model-unique items unless they are of particular interest.

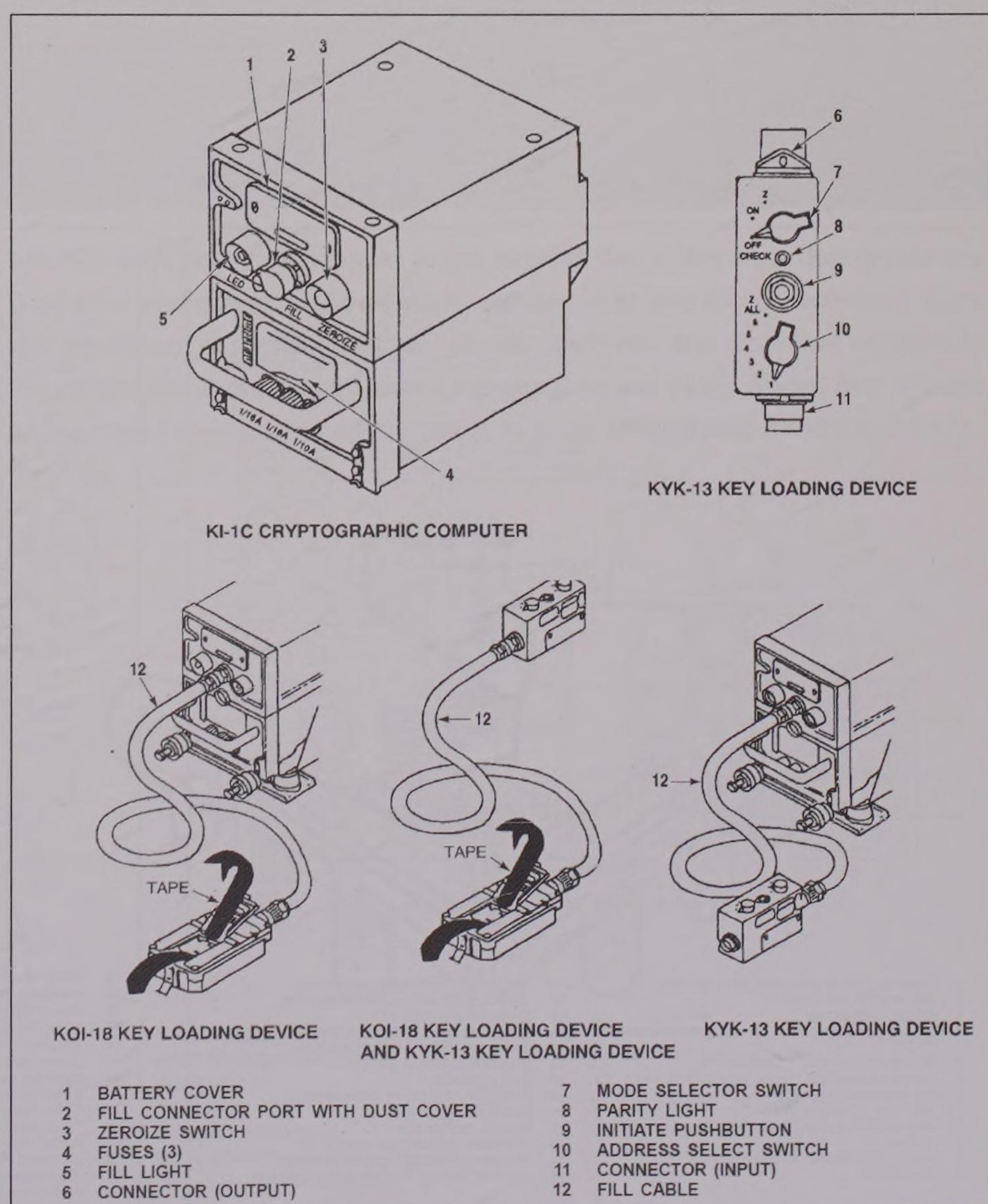
'For ground emergency procedures, I would tell Ground what I expected him to do in case of an engine fire during start or other ground

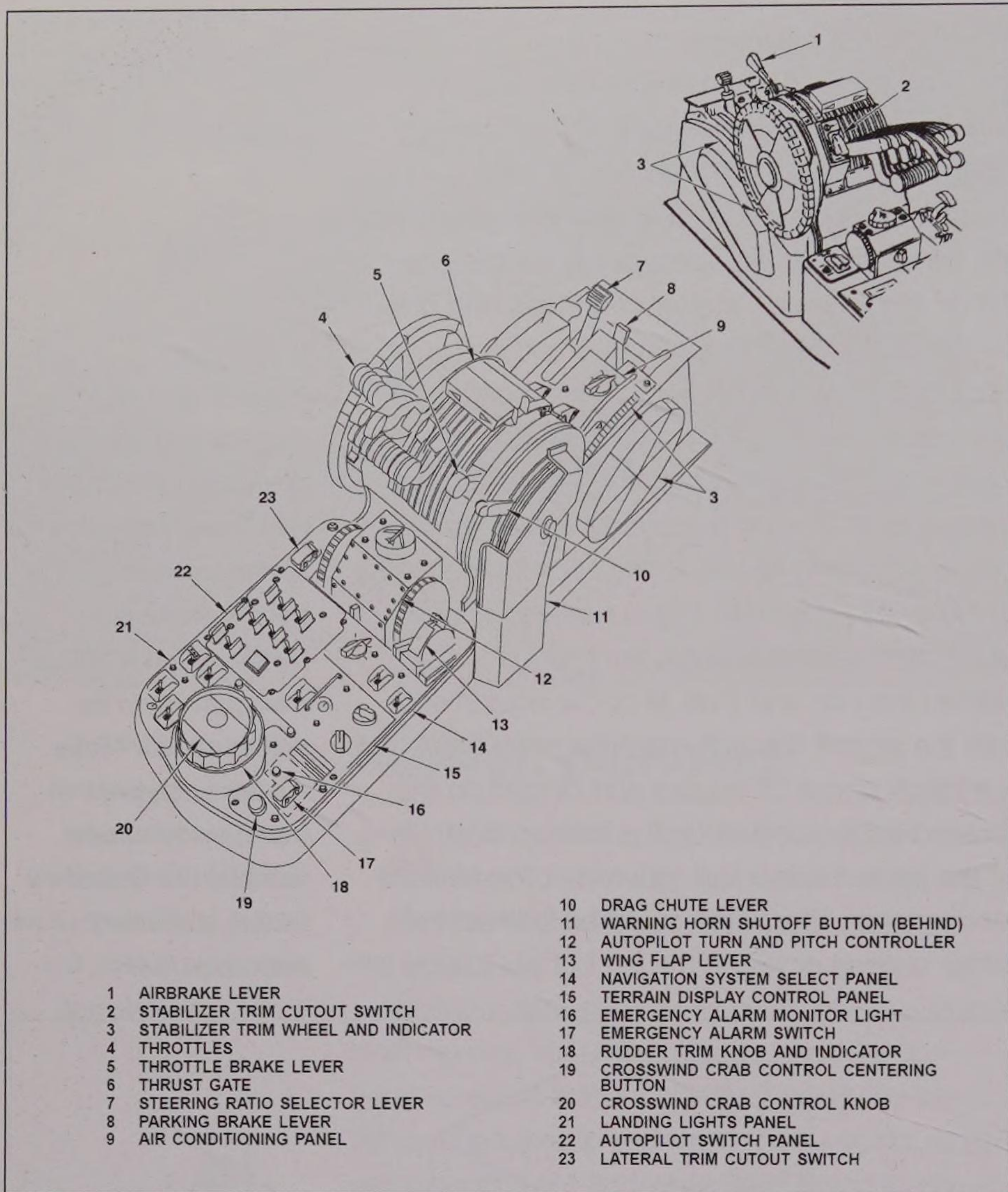
emergency, and what he could expect me and the crew to do. I would also tell him to make sure any equipment stowed in the 47 section (a large, relatively empty section of the fuselage located aft of the aft landing gear and ahead of the tail section, used occasionally for stowing things like spare oil, starter cartridges and drag chutes during deployments) was secured.

I would brief Ground on which direction we planned to taxi out and our taxi sequence if we were in formation with other bombers. Finally, I would brief Ground to connect the external power source to the jet at the appropriate time.

'After this checklist was completed and all questions were answered, the crew would unload the bus and load all of our equipment into the aircraft through the crew entry hatch – a hatch about 2ft square and hinged on the forward edge, located on the bottom centreline of the jet and a few feet forward of the forward landing gear. The hatch could be latched from either outside or inside the jet, but could only be

BELOW The KOI-18 code loading device plugs into the KI-1C cryptographic computer and allows the crypto keys for the Mode 4 IFF transponder to be programmed. Mode 4 is an encrypted transponder mode used by the United States and allied nations. (USAF)

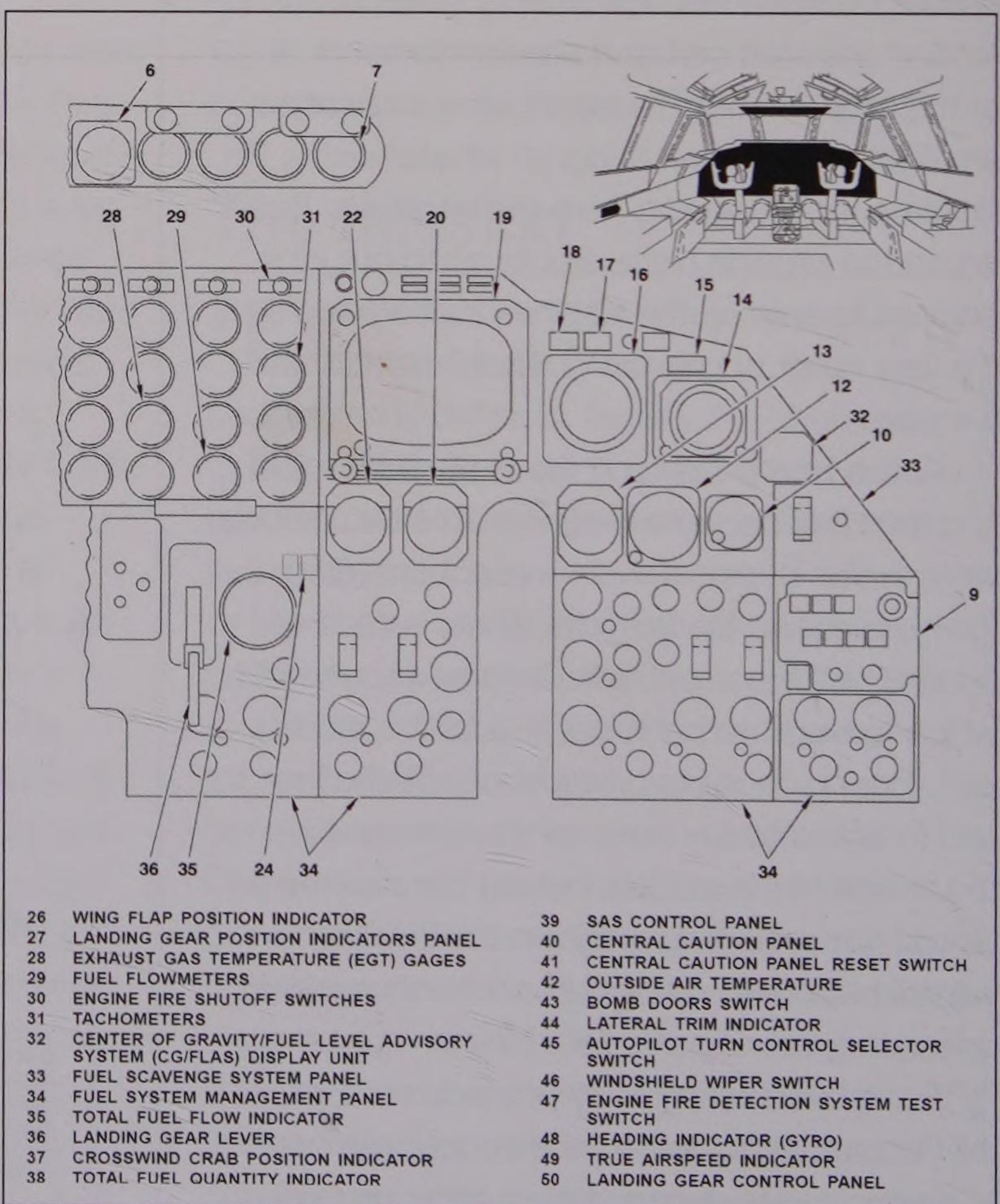
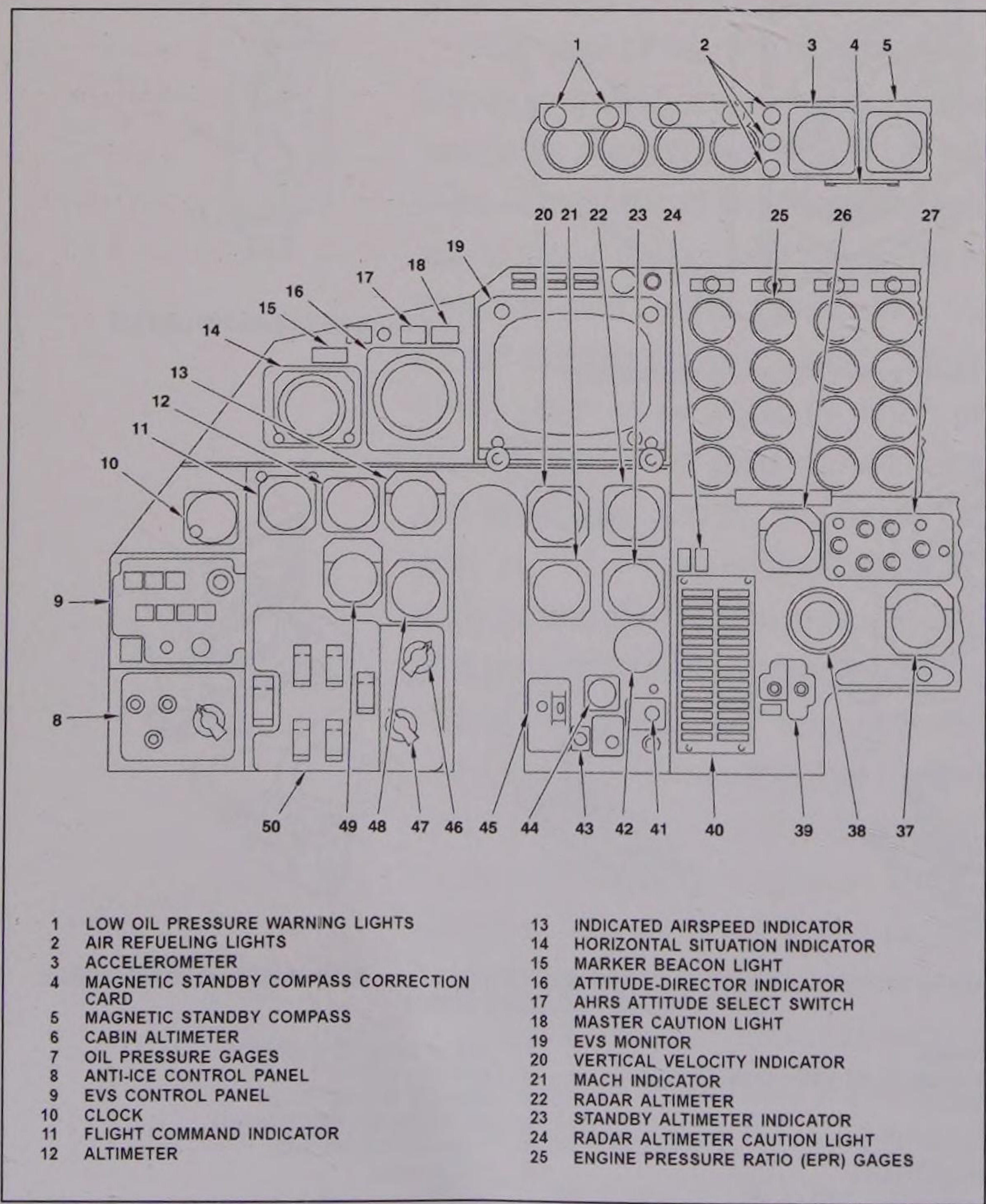




locked from inside. It contained two steps that led into the lower crew compartment, where the nav team operated. A sliding grate could be positioned over the hatch opening during flight so that you didn't have to stand directly on the closed hatch itself. A narrow ladder led up to the upper crew compartment, where the pilots and defence team lived.

The pilots, of course, were at the front of the jet, with the AC seated in the left-hand ejection seat and the co-pilot on the right. Behind the upper-deck hatch (also equipped with a protective grate), and facing towards the rear of the jet, sat the EWO on the left (as you faced the rear), and to his right the gunner. Between the pilots at the front of the jet and the defence team approximately 15ft behind them was a narrow passageway between two large banks of electrical circuit breakers (called load centrals), a small oven,

LEFT AND BELOW The following three illustrations provide a numbered guide to the instrumentation and switches for the pilot's station (left), aisle stand (middle) and co-pilot's station (right). (USAF)

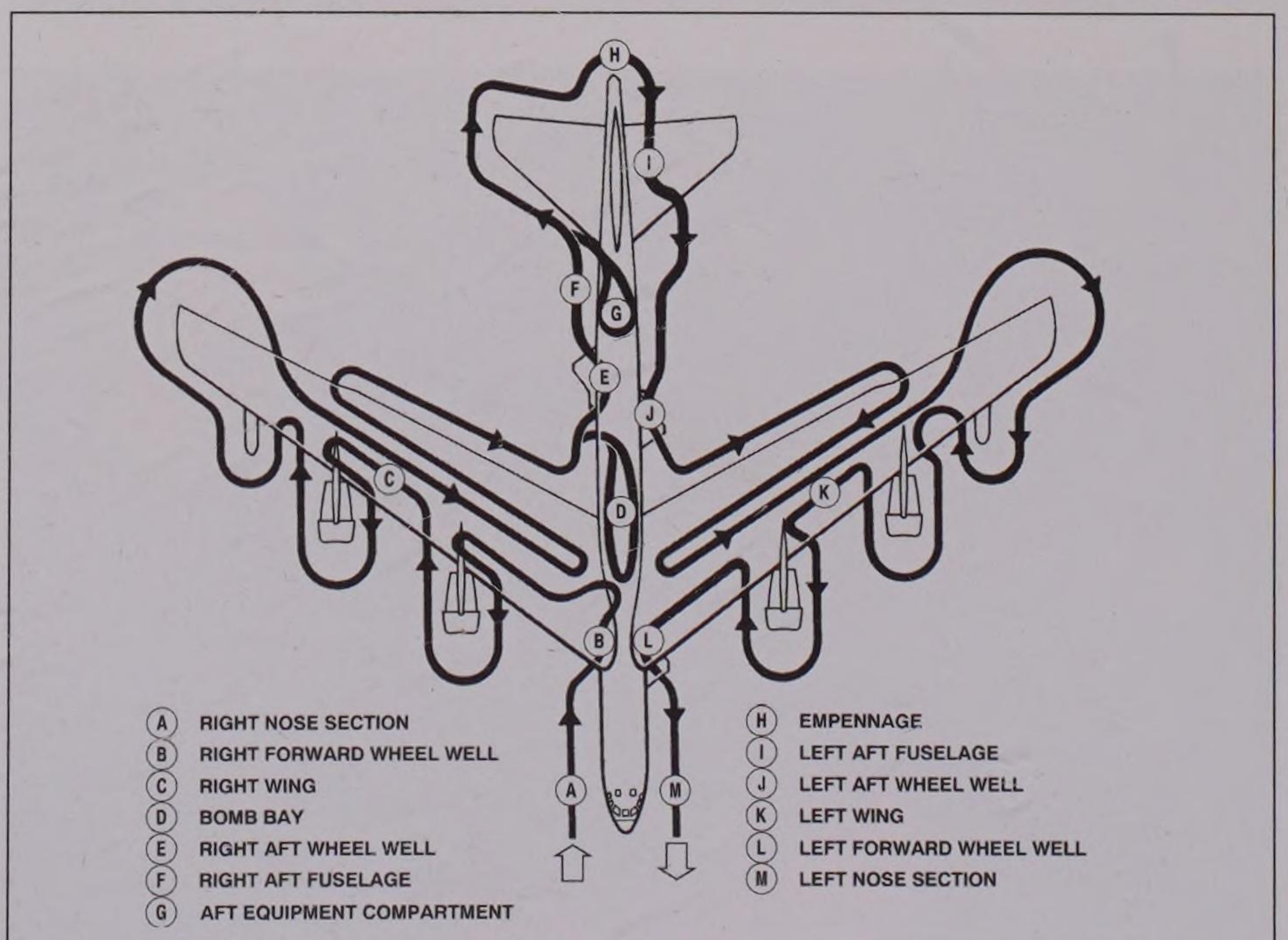


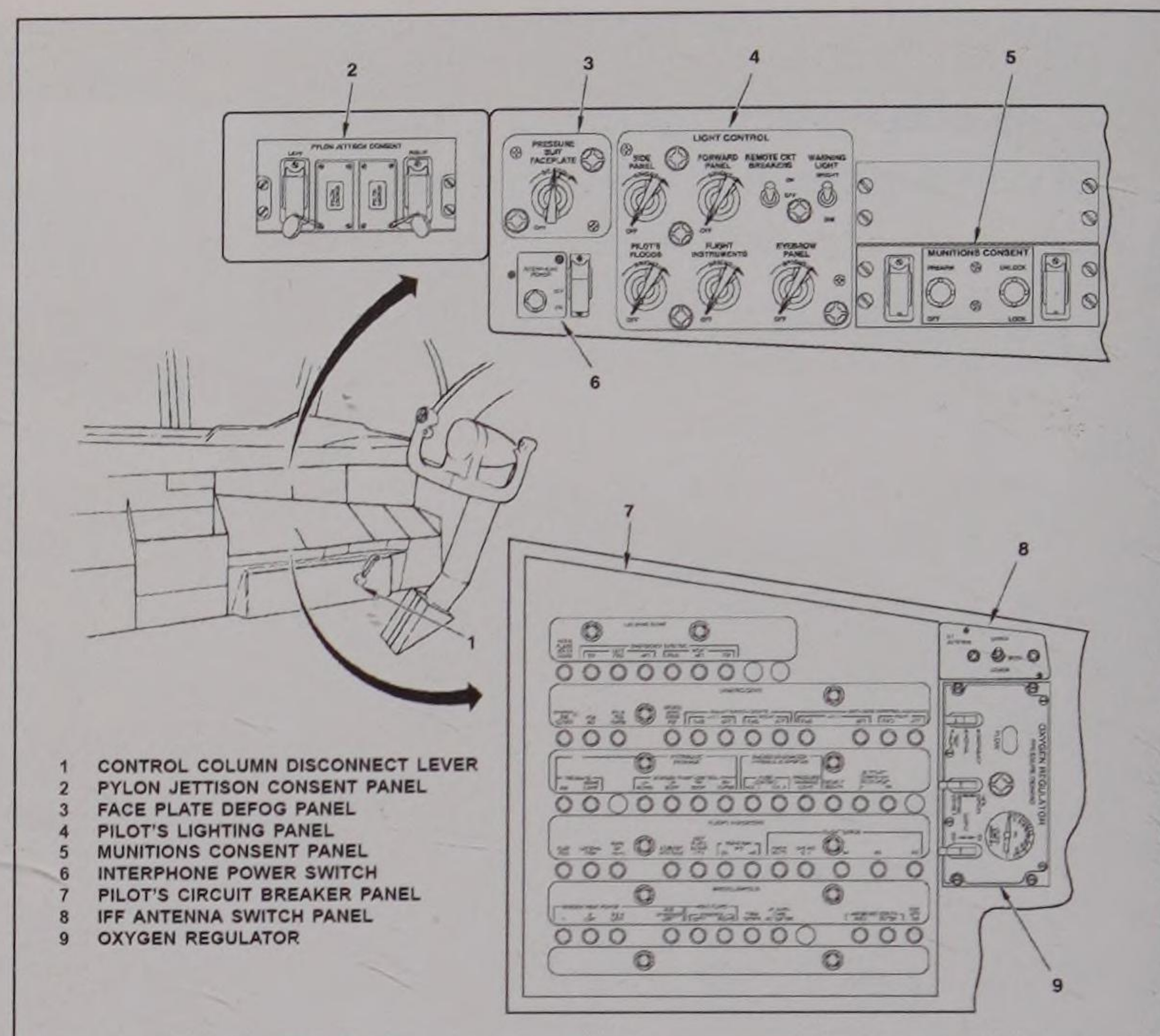
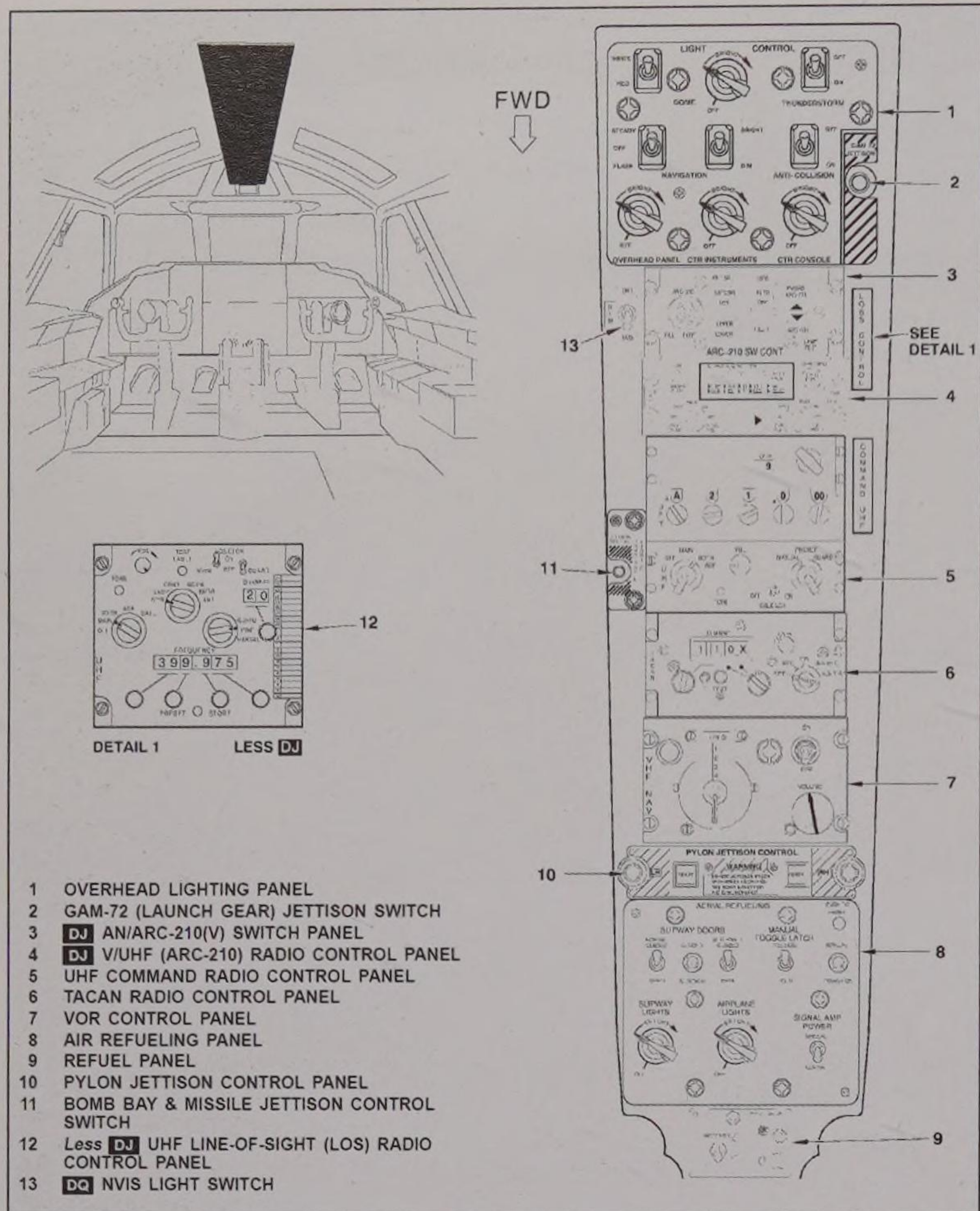


the defence instructor's seat (which doubled as the crew toilet) behind the EW's ejection seat and, on the B-52H, a bunk with a mattress which could be used during certain phases of flight for a crew member (normally a pilot) to get a quick nap. Also, located between and slightly behind the pilot and co-pilot ejection seats was the instructor pilot's seat. This seat was mounted on transverse rails, thus allowing it to slide left out of the way behind the pilot's ejection seat or to the right where it would be centred just behind the centre console, allowing

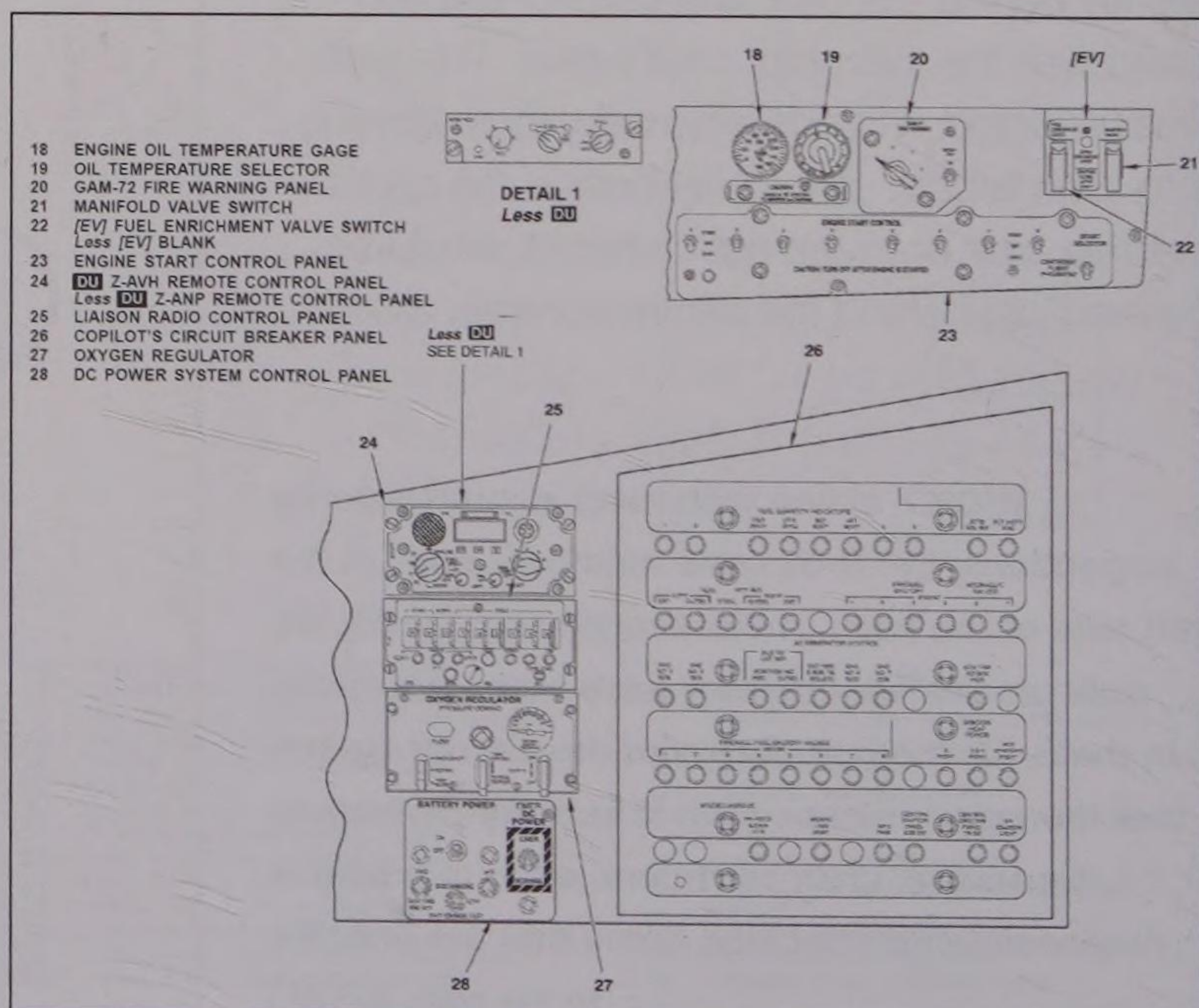
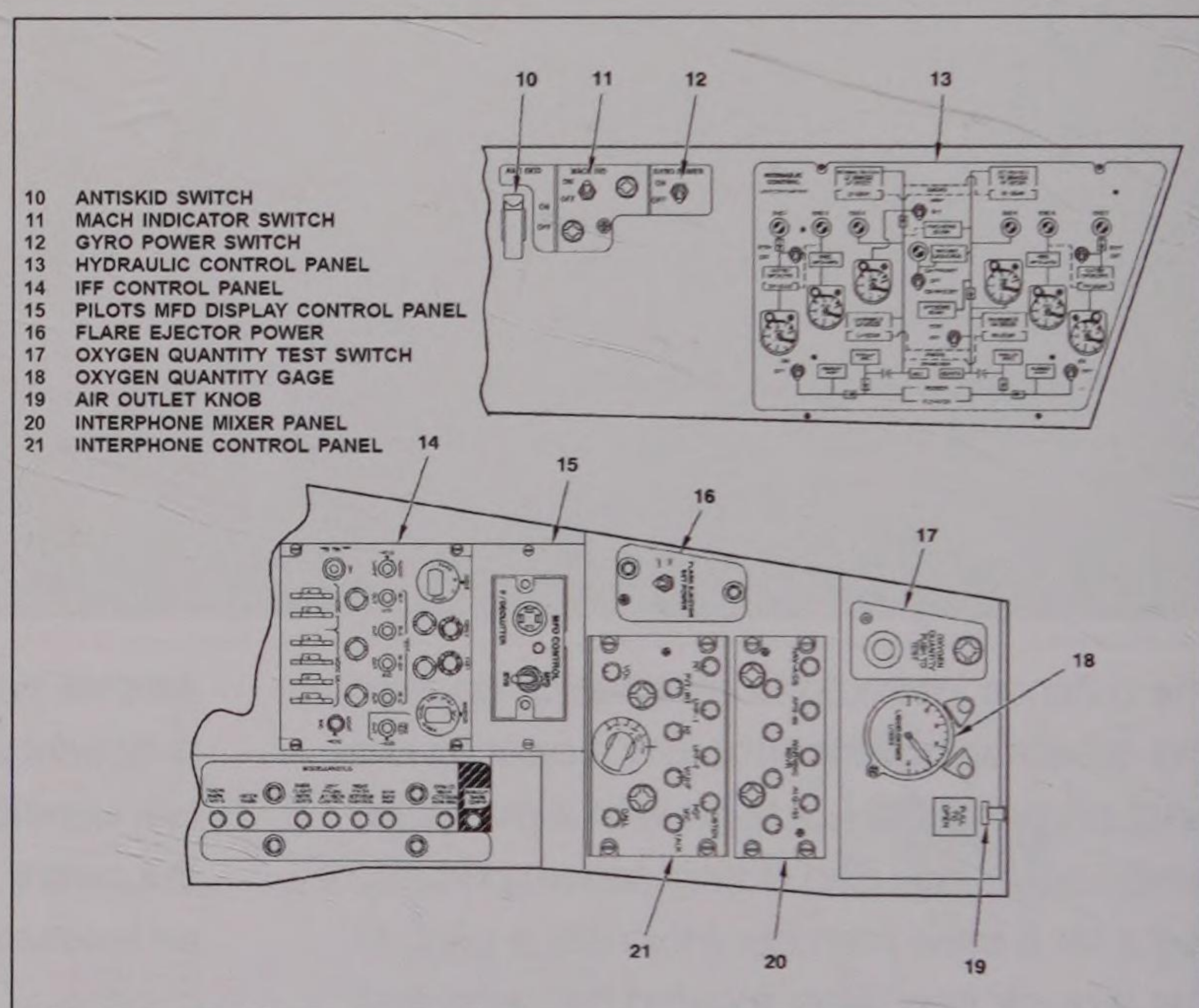
RIGHT In line with most aircraft exterior inspections, the B-52 crew members start at the left side of the nose of the aircraft and, facing aft, walk clockwise until they have come full circle. In the B-52, the complexity of the aircraft means that the exterior inspection is actually performed by several crew members, each of whom is responsible for checking items that are specific to his role. (USAF)

ABOVE With no power applied to the aircraft, this is the view that greets the B-52 pilot and co-pilot. The cockpit appears wide and roomy, although there is a significant expanse of control panels, switches and dials that extends to the centre stand and to two side consoles (one per pilot). Above (not shown), an overhead console provides access to radio and lighting controls. (USAF)





THIS PAGE The overhead panel (above) and the pilot's and co-pilot's left side panels (above right and middle) and right side panels (below right and below) respectively. (USAF)



RIGHT The pilot – also known as the aircraft commander, or AC – sits on the left side and the co-pilot on the right. Between them, a rail-mounted seat is provided for an instructor pilot. (USAF)

the IP a good view of, and access to, both the pilot and co-pilot positions.

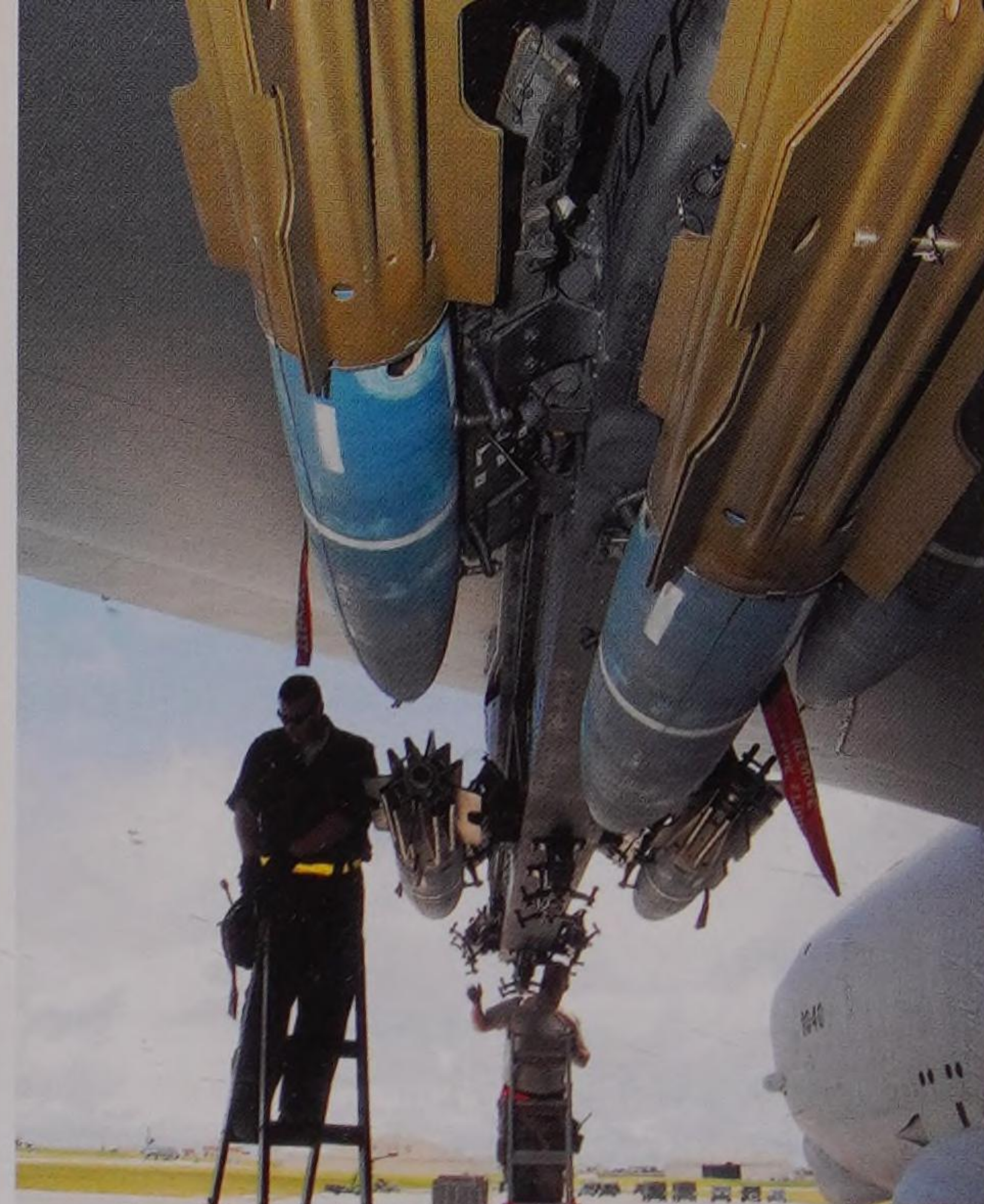
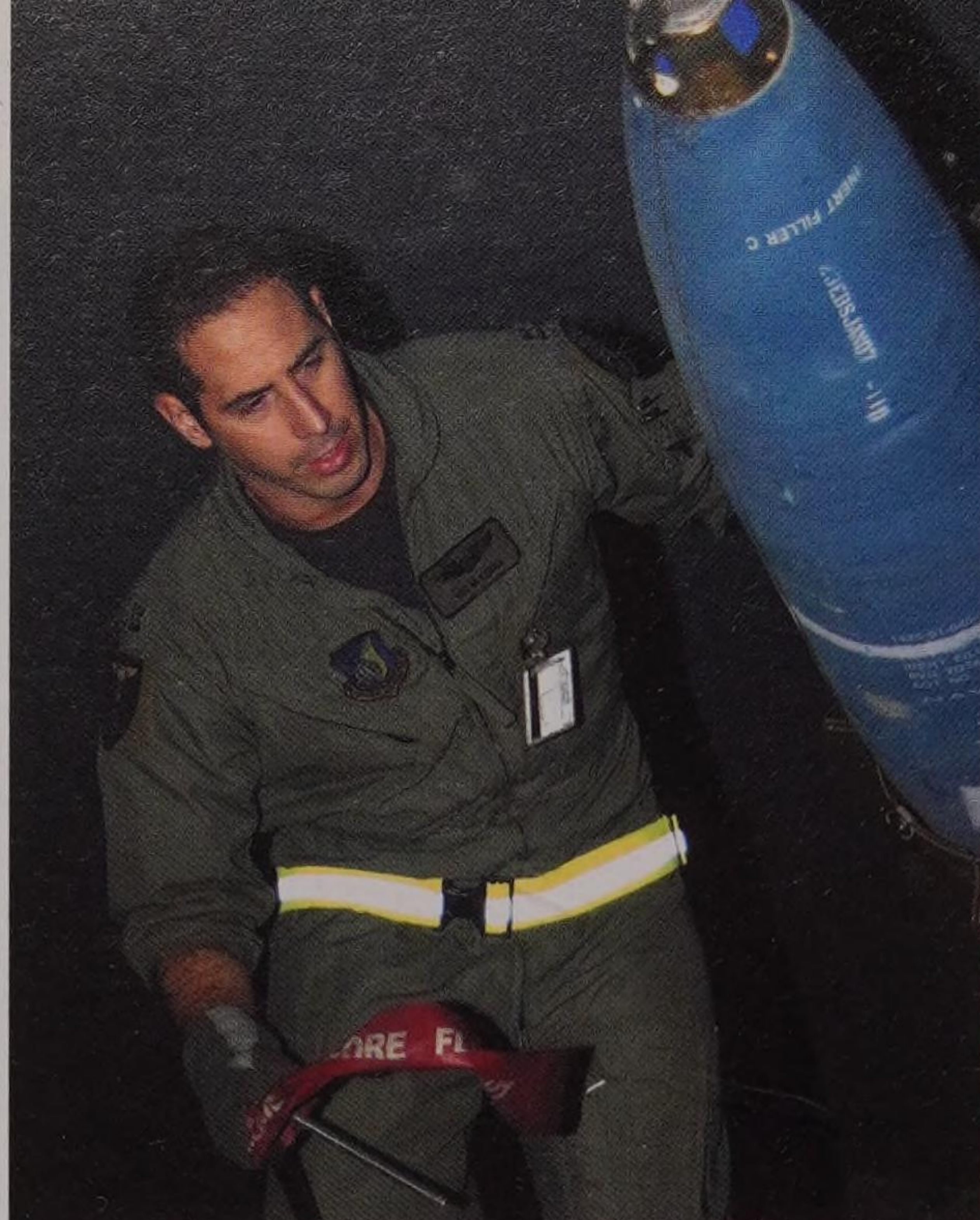
‘After loading the crew’s equipment, the crew would split into three groups: pilots, offence (nav) team and defence team. The offence and defence teams would inspect those portions of the jet pertaining to their particular job function, while the pilot team would further split up and inspect the exterior of the jet, with the pilot taking one half of the jet from nose to tail and the co-pilot the other half. This was called the “walk-around”. According to the Dash One, “Because of the size and complexity of the aircraft, the detailed inspection will have been completed by qualified ground crew personnel. The flight crew exterior inspection is an inspection of general aircraft condition. This inspection is based on the assumption that the flight crew is merely accepting the aircraft for flight with emphasis on the items that affect the safety of flight. During the inspection, emphasis will be directed toward checking for hydraulic leaks, fuel leaks, and general condition.” There was no specific checklist for this inspection and often, to expedite the process, I (as the AC) would do the entire inspection or, if we had one flying with us, we would have the extra pilot do it for us.

‘Upon completing the walk-around, we would climb up the hatch and the ladder and take our seats at the front of the jet. Actually, as we (AC and CP) were moving to our seats we would start the next check, which was the “Interior Inspection” checklist. The main purpose of this was to pre-position switches

CENTRE AND RIGHT The two navigators are located on the lower deck, facing rearwards. The radar-navigator sits in the left seat (when looking aft), and the navigator in the right seat. Above them are located the EWO and former aerial gunner’s seat. (USAF)



RIGHT AND FAR RIGHT Inert stores are painted blue in order to distinguish them from live stores. Here, a B-52 crewman preflights inert Mk82SEs loaded on an HAS. (USAF)



and levers so that nothing would inadvertently actuate when electrical power was placed on the aircraft or when the engines were started and hydraulic power was placed on the aircraft.'

Engine start

'For peacetime engine starts we used high-speed air bled from the small jet engine in the start cart. This air was routed via a large hose up to engine pod No2 (engines 3 and 4). As the start cart engaged, Ground would announce the volume of the airflow from the start cart in pounds

ABOVE AND RIGHT High-speed air bled from the small jet engine in the start cart. This air was routed via a large hose up to engine pod No2 (engines 3 and 4). As the start cart engaged, Ground would announce the volume of the airflow from it in pounds per square inch – normally at least 30psi was needed. (USAF)



per square inch (psi) – normally we needed at least 30psi. After Ground has cleared the aircraft externally to start engines, the pilot would announce ‘Starting No4’, the co-pilot would place the No4 engine starter switch to “start”, and high-pressure air would start the No4 engine turbine section spinning up to a rate that would support combustion once fuel was introduced. At 15% rpm on the engine tachometer, the pilot would advance the No4 engine throttle from “closed” to “idle”. As the engine rpm moved through 45%, the co-pilot would place the No4 starter switch to the “cont” (continuous) position. Engine No4 would be allowed to stabilise at idle for two minutes, then the remaining engines would be started.

‘However, from this point on high-pressure air from previously started engines (instead of from the start cart) would be used to supply air to the remaining engines to get their turbines spinning, using a manifold system which would allow air from one or more engines to be routed to other engines as necessary. Thus, after the two-minute wait, the pilot would announce “Starting No5”, the co-pilot would place the No5 starter to “start”, the pilot would advance the No4 throttle to a high enough rpm setting to ensure sufficient airflow from that engine through the air manifold system to the No5 engine for starting and at 15% rpm on engine No5, the pilot would advance the No5 throttle from “closed” to “idle”. As No5 passes through 45% rpm, the co-pilot places the starter switch to “cont”. Engine #5 is allowed to idle for two minutes, then the remaining six engines were started, with the pilot responsible for engines Nos1, 2 and 3 while the co-pilot started engines 6, 7 and 8.

‘Since the noise level in the cockpit was deafening with two engines set at a high rpm and the other six engines being started, and because the co-pilot was watching his three engines for signs of a hot start and for the proper rpm to advance the throttle and to place the starter switch to “cont”, the pilot used hand signals to indicate to the co-pilot when to place the starters to “cont” for his three engines. After all six remaining engines were started, the starter switches were all in “cont” position and engines Nos4 and 5 were retarded to “idle”, checklist Step 8 was called. Following engine start, the jet’s four electrical generators were



ABOVE The heavy hose of the start cart requires two maintainers to manhandle it into place. The cart is used for nearly all starts. The exception to the rule is typically nuclear scrambles, during which MXU/4A starter cartridges provide the most expedient method with which to crank the eight engines. (USAF)

BELOW A maintainer removes the chocks from a 5th Bomb Wing B-52H on a sunny August day. The B-52 crew would at this point have already strapped into their ejection seats. (USAF)



placed online, transitioning the aircraft from external to internal electrical power, and the aircraft air conditioning system was turned on. This provided cooling air not only for the crew members in the crew compartment but also, and more importantly, for the gunner's and RN's electronic equipment so that they can start turning their equipment on prior to take-off.

'The aircraft was then cleared of any obstructions, such as the start cart, tool boxes, etc, which would impede its taxiing, and the rudder/elevator hydraulic system was turned on. Next, an intricate check of the stabiliser trim system was conducted by the pilot, co-pilot and ground crewman. This involved running engines Nos4 and 5 up to 82% rpm; then the co-pilot and pilot took turns activating the stabiliser trim system using their "coolie hat" trim switches on their control columns. They also checked the functioning of the stabiliser trim cut-out switch on the centre console, the force cut-out switches in the control columns, and the manual trim wheel. All the while, Ground told the pilots the direction of movement of the horizontal stabiliser to make sure that the trim system hadn't been wired in reverse during maintenance. The crew got into their parachutes, the bomb doors were closed, Ground pulled the chocks and disconnected his interphone cord, the anti-collision and navigation lights were set and we were ready to taxi.

'Just prior to taxiing, the co-pilot calls Ground Control to request clearance to taxi. If he hasn't already put our clearance on request, he does so at this time. If there is a functioning ATIS (automatic terminal information service) at the base, we would have already monitored that on the other radio and copied the necessary information. ATIS is an automated radio broadcast on a designated frequency for a specific airport or base which broadcasts important information that pilots operating into or out of that base need to know, such as the active runway, altimeter setting, current weather, airfield NOTAMs (Notices to Airmen), etc. Not every field has ATIS, but for those that do, having a pilot listen to ATIS before calling Ground Control saves Ground from having to repeat the same information over and over for different pilots. Putting our clearance on request is pretty much just that – our request through

the Ground Controller to the FAA to activate our requested flight plan that was filed when we were at Base Operations. We have to have a clearance from the FAA to take off and enter the Federal airspace system. At some point after we've started to taxi out, Ground Control will call us back with our clearance. Normally it's what we've filed for and includes a Standard Instrument Departure, or SID, from our base to get us into the airspace system. The co-pilot writes down the clearance and notes any changes from what we've filed.'

Taxi

'Brakes are applied as soon as we're rolling forward, to make sure they're working properly; flaps are lowered (all B-52 take-offs are made with full flaps), and the turn and slip instruments (heading indicators, magnetic compass and the 'needle and ball' turn and slip indicators) are checked for proper movement during turns.

'Next, we check a system that is, as far as I am aware, unique to the B-52. During heavy crosswinds, any aircraft on a final approach will tend to be blown off course by the wind. There are two main ways pilots correct for this – the "wing low" method and crabbing into the wind. Wing low requires the pilot to fly the final with the upwind wing of the aircraft lower than the downwind wing while keeping the fuselage of the aircraft aligned with the runway, essentially banking into the crosswind at the same time as the wind is attempting to blow the aircraft downwind. On an aircraft with the wingspan of a B-52 (185ft), this would cause the upwind (lowered) wing to come unacceptably close to the ground on short final. The other method, crabbing, involves actually turning the nose of the aircraft into the crosswind – in essence flying the aircraft into the wind as the wind attempts to blow the aircraft off course. This results in the aircraft flying down final "sideways". As the aircraft flares for landing, the pilot kicks in some rudder at the last second to straighten out the aircraft's heading and align it with the runway. Using this method, the wings are kept level while flying down final. However, if the aircraft heading is not straightened out and aligned with the runway at touchdown, unacceptably large side

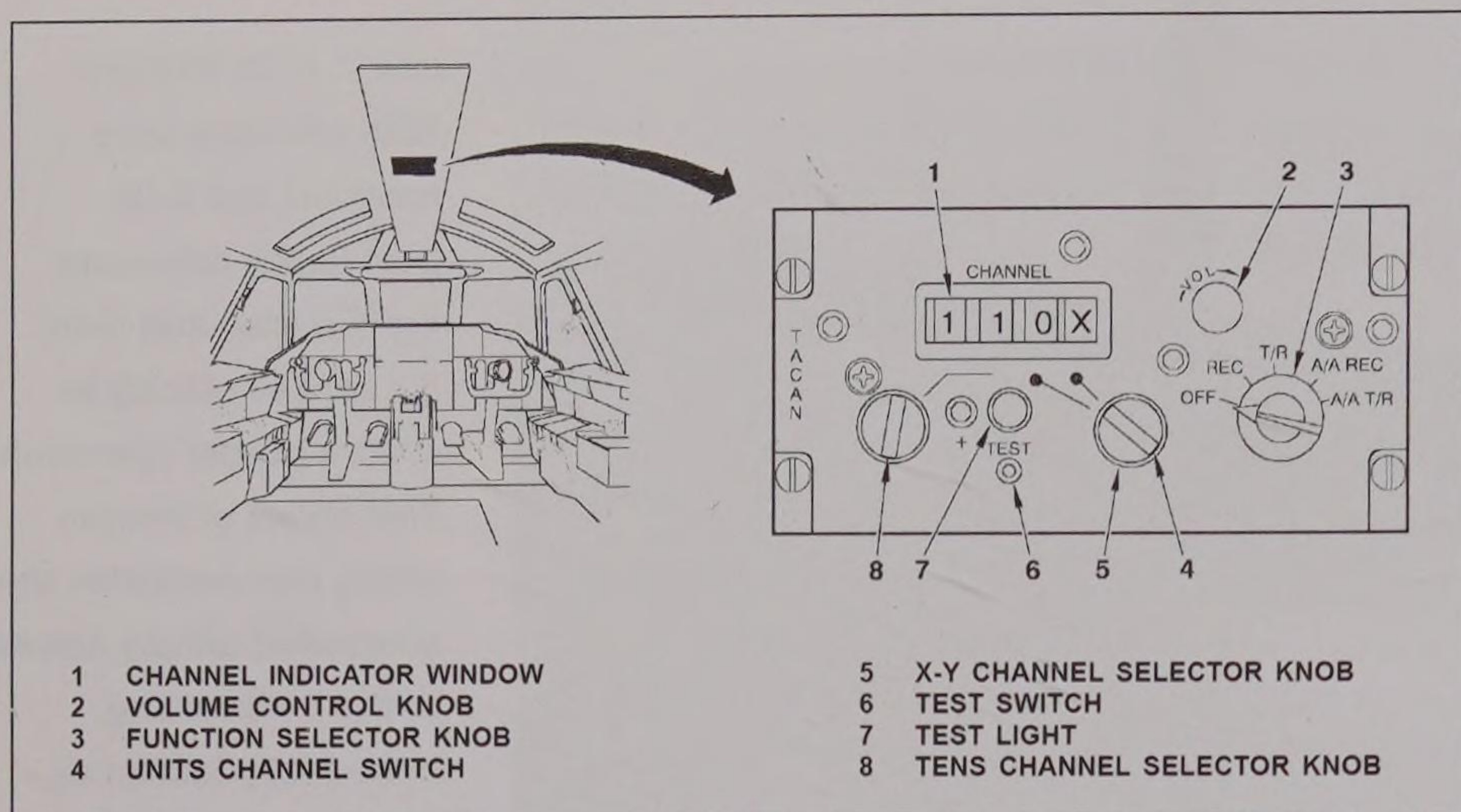
loads can be placed on the aircraft's landing gear, potentially resulting in blown tyres and a landing gear collapse on the runway.

'In a large aircraft like the B-52, delays between the time a pilot makes a control input and when the aircraft actually begins to respond mean that it is difficult for a B-52 pilot to know exactly when to start using the rudder to correct the aircraft heading prior to landing. Also, the unique placement of the B-52's main landing gear, with two trucks of four wheels towards the forward end of the fuselage and two trucks of four wheels towards the aft end, presents unique problems associated with determining where to fly the aircraft on final approach during a crosswind landing. Fortunately, the Boeing engineers and designers came up with a novel solution. In the B-52 there is a knob located on the pilot's centre console that causes the



LEFT AND BELOW
With taxi clearance received, the B-52 pilot gently advances the throttles and dabs the brakes quickly to ensure proper operation. This series of images amply demonstrates the somewhat gangly nature of the B-52 taxiing, colloquially known as 'the elephant walk'. Note how the tip gear of a fully fuelled B-52 is essential to prevent the wingtip from striking the ground even when taxiing in a straight line. (USAF)





ABOVE The TACAN is set during taxi. The control panel is located on the overhead panel between the pilot and co-pilot. (USAF)

main landing gear trucks to be physically turned up to 20° from the aircraft centreline, thus allowing the main landing gear trucks to be aligned with the landing runway while the rest of the aircraft is flown crabbed into the wind in a wings-level attitude, and therefore eliminating the requirement to kick in rudder at the last second to align the fuselage with the runway. When the B-52 was first unveiled to the public in the early 1950s this crosswind crab system was so unusual that it was declared to be classified, and photos of the system in use were airbrushed out of early pictures of the B-52. For

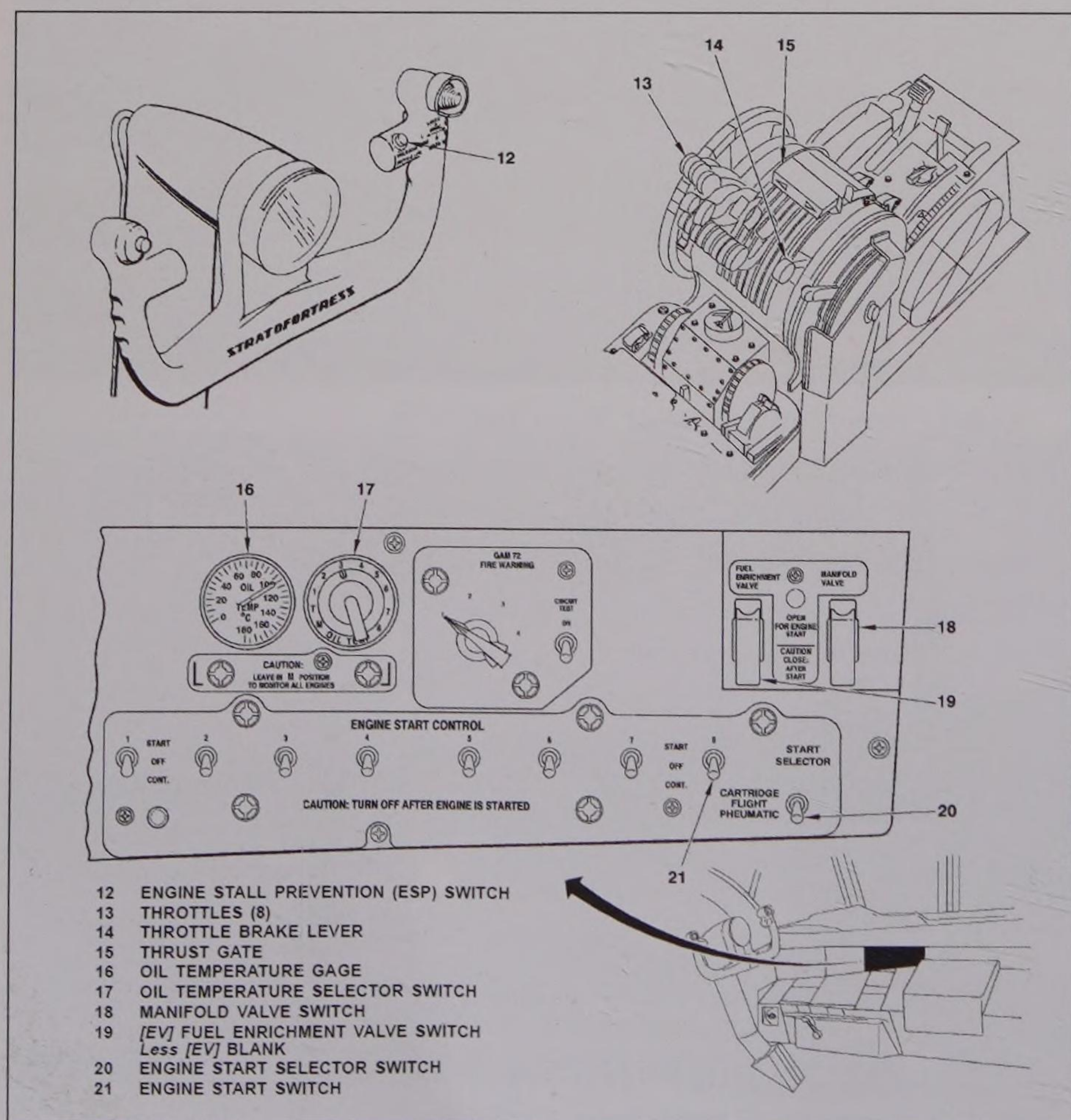
the B-52 pilot, this system allows take-offs and landings under extreme crosswind situations of up to 43kt of direct crosswind – a very useful capability to have in an aircraft whose wartime mission requires it to be able to take off and land under any circumstances, usually at a base where there is only one runway (thus eliminating the possibility of switching to another runway which is more nearly aligned with the wind).

'This crosswind crab system is the focus of our next check. To do so while taxiing, we introduce a small amount of crab manually (using the knob on the centre console), and then centre the system using the automatic centring button next to the knob.

'With the crab system working, the co-pilot will refer to his fuel system set-up pages in his abbreviated flight crew checklist and determine which fuel panel configuration is appropriate for take-off with the amount of fuel on board. He will ensure that it is set, then he will take control of the jet from the pilot and allow the pilot to check the configuration. Transfer of control of the aircraft is always done in a positive manner and over the interphone (P: "You have the jet"; CP: "Roger, I have the jet"), even on the ground – somebody always has control of the jet.

'The TACAN (tactical air navigation) receiver is set to the TACAN transmitter located at the field and checked at a ground checkpoint (if available). Following this, the take-off data to be used is reviewed by the pilots and navigator – this consists of the take-off EPR (engine pressure ratio – a measure of engine thrust), thrust gate setting for the B-52H, S1 speed and time and S2 speed. Also, procedures to be used in the event an emergency occurs during take-off are reviewed.

'The thrust gate, a roller-mounted carriage which travels between guide rails located above the throttle quadrant surface at each side of the aisle stand, is checked. It spans the throttle quadrant forward of the throttles,



LEFT During pre-take-off checks, the pilots set the thrust gate (15 in the schematic) to prevent excessive throttle advancement. During take-off, a button (12) can be pressed and held in crosswind conditions to activate the engine stall prevention system. (USAF)

providing a means of restricting forward travel of the throttles during operation requiring a limited amount of thrust. The B-52H's turbofan engines are powerful enough that, during lighter gross weight take-offs, go-arounds and missed approaches, the engine thrust can cause a rapid nose-up pitching moment that cannot be overcome by the available elevator authority and pitch trim, resulting in a stall and crash. The thrust gate prevents this from happening by providing a physical barrier to excessive throttle advancement. A chart is used to determine the proper thrust gate setting for take-off, using take-off EPR and the outside air temperature as entering arguments, and the thrust gate is set by means of a scissor-type lever in 5° increments.

'Continuing the checks, the pilots take turns making sure they can achieve full control displacement and that their seats, which are electrically adjustable for forward-aft, up-down and tilt positions, are properly positioned. Finally, just before taking the runway, the upstairs crew members arm their ejection seats by removing and stowing the safety pins that prevent the seat arming levers from being rotated.'

Take-off

The B-52H uses an engine stall prevention (ESP) system to control the engine compressor surge bleed valves for prevention of stalls that are caused by crosswinds during ground operations. If crosswinds of 10kt or more are blowing across the engine inlet lip, the pilot presses a button on the control yoke which opens the compressor surge bleed valves sufficiently to reduce the pressure rise across the low speed forward compressor. Once the aircraft has attained 50kt the system is no longer required. The pilot making the take-off pushes all eight throttles forward to the thrust gate and the pilot not making the take-off quickly adjusts each throttle to the proper computed take-off EPR setting, then rests his hand on top of the other pilot's hand, so that the throttles can be rapidly pushed forward should it be necessary during the take-off roll.

'Unlike some other large jets where each pilot is provided a separate but interconnected set of throttles, in the B-52 the single set of eight throttles on the centre console is "shared"

by both pilots during take-off and at other times when thrust management and/or throttle response time may be critical. The pilot making the take-off maintains control of the throttles until the expiration of S1 timing and the decision has been made to continue the take-off. At that time he will take his hand off the throttles and place it on the control yoke with his other hand in order to fly the jet off the ground using both hands. The pilot not making the take-off then assumes control of the throttles for the remainder of the take-off and locks them into position using the throttle friction lever on the co-pilot's side of the throttle quadrant.

'In the B-52, take-off performance is monitored through use of the S1 S2 acceleration monitor procedure. This procedure is based on a timed acceleration check between two indicated airspeeds which can be compared against a pre-computed acceleration rate taken from charted values prior to take-off. Use of this system virtually eliminates wind error, airspeed indicator calibration error is minimised, and no reference point outside of the aircraft is necessary. In this system, 70 knots indicated airspeed (IAS) is the initial timing

BELOW The B-52 crew use a timing system to check acceleration, with the pilot not-flying calling out timings and speeds. At 'S2', the aircraft is finally rotated into the air. Gear retraction occurs soon after and, as this Minot B-52H shows, the tip gear retract at a faster rate than the two sets of main landing gear. (USAF)



speed at which timing is started to determine acceleration characteristics of the aircraft. As the aircraft accelerates down the runway, the pilot not making the take-off calls out, "Coming up on 70 knots" at 60 knots, and then calls out "Now" at precisely 70 knots IAS on his airspeed indicator. The navigator starts his stopwatch. This also provides an opportunity for the other pilot to cross-check his airspeed indicator – if the difference between the two pilots' airspeed indicators at the 70 knots check exceeds 6 knots, the take-off must be aborted. Approximately three seconds before the expiration of S1 timing, the navigator calls out, "S1 time", and precisely at the expiration of S1 timing the navigator calls out, "Now!" At the same time, the pilot making the take-off checks his airspeed. If the jet has accelerated to at least the S1 minimum IAS, the take-off is continued and the pilot announces "Committed". If S1 minimum airspeed has not been obtained, something is wrong with the aircraft that would jeopardise the ability to continue the take-off safely, the take-off will be aborted, and the pilot will announce "Abort". Typical values for S1 speed and timing would be in the neighbourhood of 110 knots for S1 speed and 15.5 seconds from 70 knots to S1 for timing.

'Assuming that the take-off is committed, the pilot making the take-off releases the throttles and puts both hands on the control yoke, while the pilot not making the take-off now assumes control of the throttles and continues to monitor the aircraft's take-off roll, engine instruments and airspeed. About 5 knots below S2 speed, he calls out, "Unstick speed", and exactly at S2 speed he calls out, "Now". The pilot making the take-off pulls back on the control column at unstick speed and the aircraft flies off the runway.

'At this point, several activities start happening at the same time. I'm entering the Federal airspace system with a large, fast jet among other large, fast jets and I've got a mission to do, along with five other crew members, involving multiple complex and interrelated systems in a demanding and dangerous environment. Pilots are taught to prioritise their actions according to a simple rule – aviate, navigate, communicate. In other

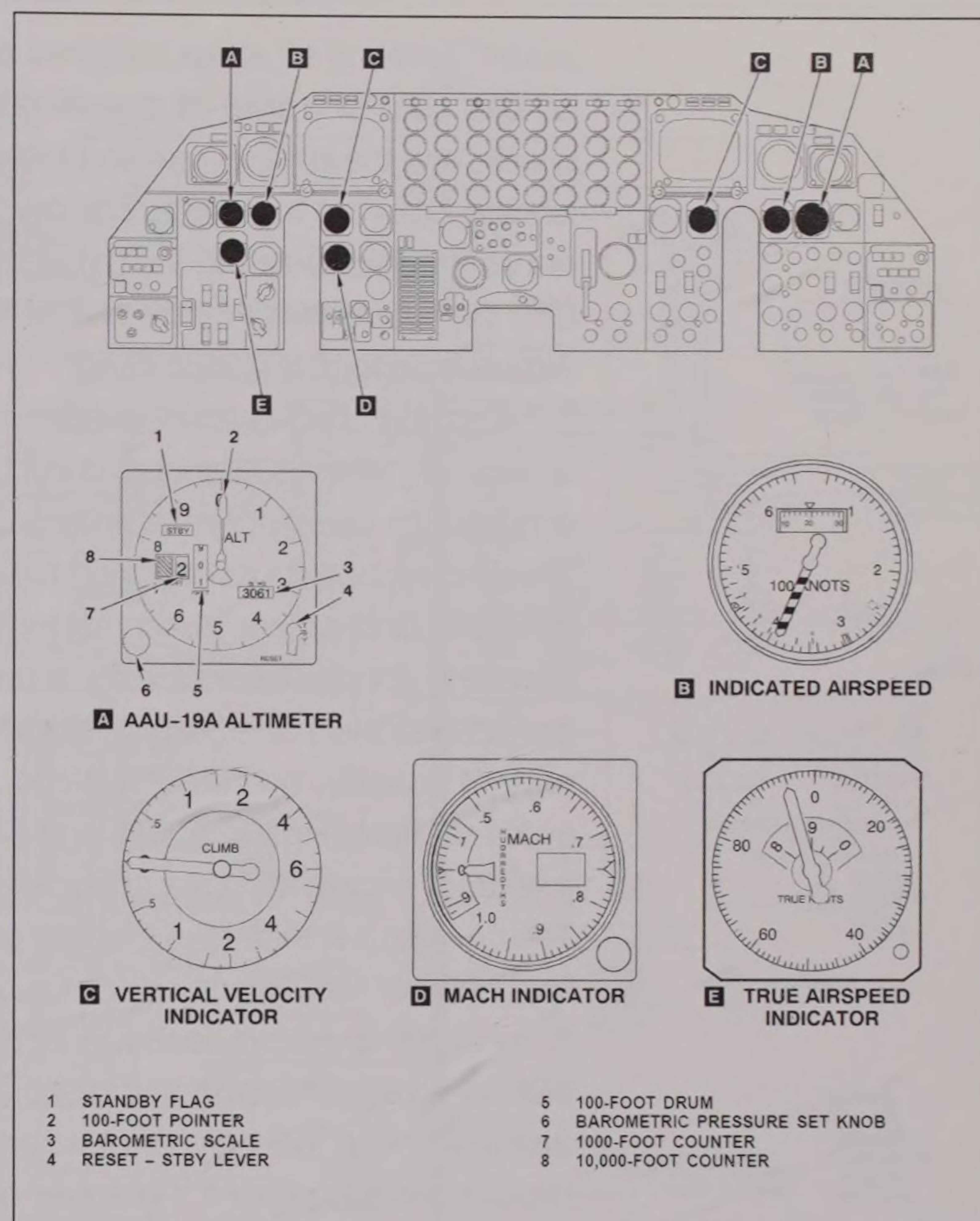
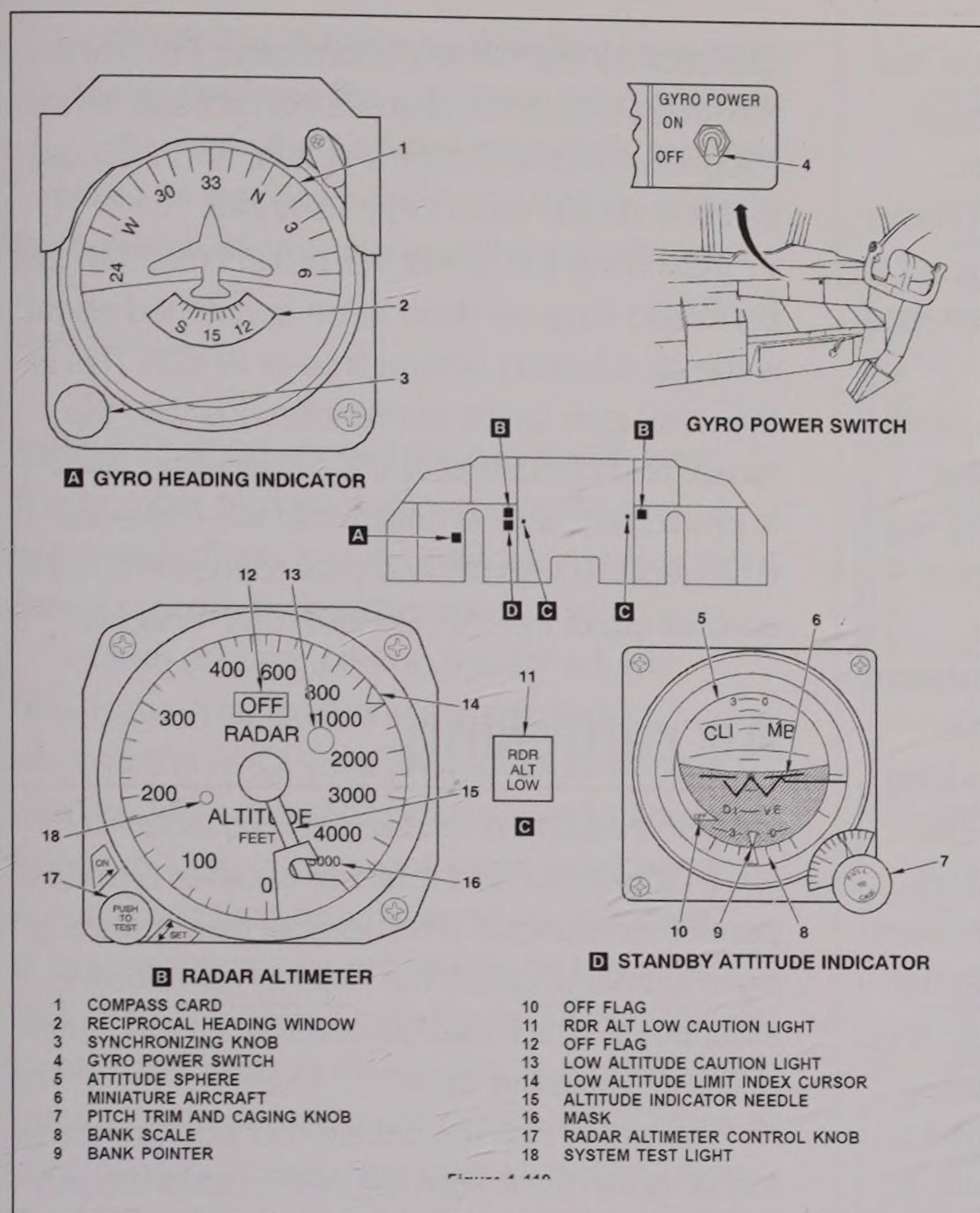
words, fly the jet first, then figure out where you need to be going and go there, and, as last priority, tell someone on the ground what you're doing. Using this rule, as soon as we break ground we start the "After Take-off – Climb" checklist.'

After take-off

As soon as we break ground and have two positive climb indications on the altimeter and VVI (vertical velocity indicator, which shows our rate of climb/descent), the pilot flying the jet applies the wheel brakes to stop the wheels from spinning and possibly causing damage to the wheel wells, and then calls for gear up. The other pilot raises the landing gear lever to retract the gear, makes sure the warning light is out and that all six gear indicate up and locked.

'We accelerate to 180 KIAS (knots indicated air speed), continue climbing to our initial assigned altitude and prepare for flap retraction. While this is happening, the non-flying pilot calls Departure Control and checks in. After we've reached at least 1,000ft AGL (above ground level), 180 KIAS and have at least 1,000fpm VVI, the flying pilot calls for flap retraction and the non-flying pilot places the flap lever in the "up" position. The non-flying pilot calls out, "Flaps coming up together, flaps 50%, flaps 30%, last 20%, flaps up, lever off" at the appropriate points during flap retraction. The pilot flying the aircraft adheres to a speed schedule as the flaps are retracting, as follows: flaps 100% (full down) = 180 KIAS; flaps 50% = 200 KIAS; flaps 30% = 210 KIAS; and flaps 0% (full up) = 230 KIAS. The flaps provide a lot of extra lift, as well as significant drag, so the pitch attitude of the aircraft changes significantly during the one minute required for flap retraction, and the pilot flying the aircraft must devote his full attention to controlling aircraft pitch and airspeed during this time.

'During the flap retraction sequence we maintain course straight ahead; however, once flaps are up we manoeuvre the jet as necessary to fly our assigned departure track. As we continue to accelerate to 280 KIAS and fly the departure, the non-flying pilot sets the throttles to NRT (normal rated thrust) by

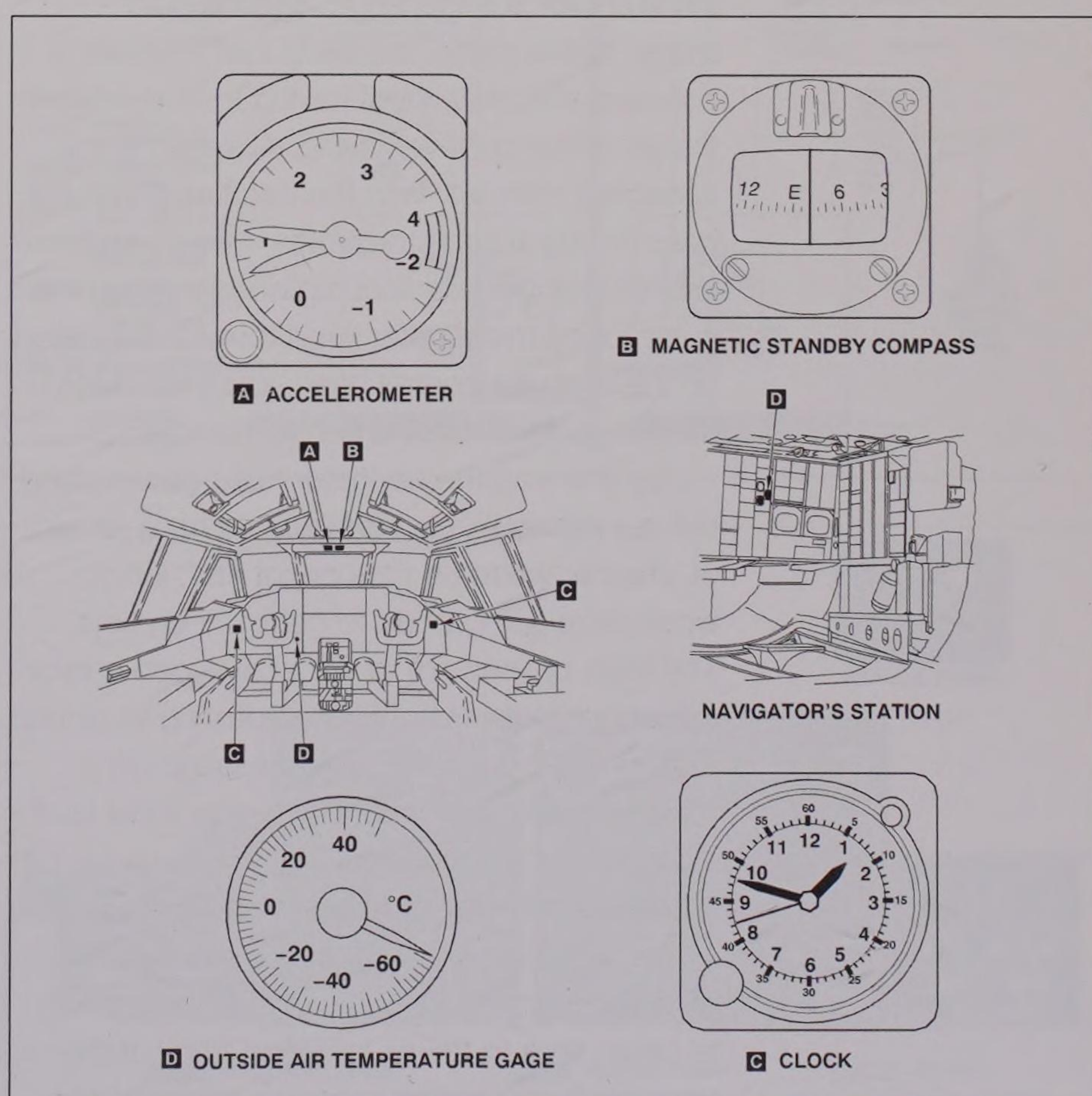


referencing a chart in his abbreviated checklist. Prior to passing 10,000ft, the co-pilot sets the air conditioning system to 7.45psi, providing cooling air for the crew and electronic systems. The air refuelling slipway doors are cycled open then closed to eliminate moisture that may have collected in them on the ground and that would then freeze at altitude, thus preventing the doors from opening for air refuelling.

'Passing 12,000ft, the pilots call for an oxygen check. The pilot team also confirms that the crew cabin is pressurising properly and that the appropriate cabin altitude is being maintained (step 9). After the 12,000ft oxygen check, the co-pilot once again refers to his abbreviated checklist to determine the appropriate fuel panel sequence for the amount of fuel on board and whether external cruise missiles are being carried. After setting the panel, the pilot transfers control of the jet to the co-pilot so he can check the co-pilot's fuel panel settings.

'Passing 18,000ft, the pilot, co-pilot and navigator set 29.92 in the Kollsman windows of their altimeters – this is the standardised altitude above which all aircraft use 29.92 as the standard altimeter setting and refer to altitudes as "flight

ABOVE AND BELOW During all phases of flight, the pilot and co-pilot monitor their electrical (above left), pitot-static (above right) and miscellaneous (below) instruments on the forward console. (USAF)



levels". Levelling off at our assigned altitude, the co-pilot calls for a level-off oxygen and station check, and the landing, taxi and crosswind landing lights are turned off. The oxygen checks are completed as earlier, the thrust gate is set at 85°, the starter switches are placed to "off", and the crew perform a station check.

'A station check is performed by the pilots at level-off, every 30 minutes during cruise, and prior to leaving crew positions during flight. The check consists of checking for system operation and proper switch settings for prevailing conditions, including circuit breakers, generators, fuel panel, engine instruments, oxygen quantity, hydraulic systems, anti-icing systems, updating the AHRS and CG/FLAS (centre of gravity/fuel level advisory system). The co-pilot will then take the first of an hourly sequence of fuel quantity readings, using the "Form 200" to record each fuel tank's reading, the fuel totaliser reading and plotting the quantity on the fuel curve that was created on mission planning day. If the actual quantity is significantly above or below the curve, the crew determines the cause and whether corrective action is required.

'Finally, the CG/FLAS is initialised, and the autopilot is engaged in "altitude hold" mode. In this mode, the pilots can maintain a constant altitude without having to "hand fly" the jet, which gets very tiring. Airspeed is still controlled manually with the throttles (the B-52 does not have an auto-throttle system) and course changes are accomplished through the autopilot by means of a small turn-knob located on the autopilot control head, just behind the throttle quadrant on the centre console.

'By this time the navigator has been working out our mission timing and should have an idea of whether we're on time or not and, if not, what we're going to do to get back on time. The main options are to adjust airspeed and/or adjust our route of flight by requesting to extend a leg or cut a leg short, as necessary. On a training mission the first activity after initial level-off is usually air refuelling. The tanker we will be refuelling from may or may not be from our base – if he is, we probably already know if he took off on time and therefore if we can expect him to be on time to the air refuelling track. If the tanker is from another base, we will probably

call back to our Control (Command Post) and ask them to call the tanker's home base on the telephone and find out his status, and then call us back on the radio to let us know.

'Assuming the tanker will be on time, the next controlled time we need to be concerned about is the air refuelling control time or ARCT. This is the time upon which our rendezvous with the tanker and our usage of the air refuelling track is predicated, so it is critical that we make this time good. Thirty minutes prior to the ARCT, the co-pilot starts the "AR Rendezvous" checklist.'

Air refuelling

The standard rendezvous procedure for a bomber and a tanker is called a point-parallel rendezvous. The bomber flies toward a point in space, called the ARIP or air refuelling initial point, which can be considered the start of the air refuelling track.

'The tanker flies toward another point in space further down track from the ARIP, called the air refuelling control point or ARCP. The tanker sets up an orbit using the air refuelling track heading into the ARCP as its inbound holding leg heading, using left turns at 30° of bank.

'The two aircraft are vertically separated by 1,000ft, with the tanker above the bomber. As the tanker orbits, waiting for the bomber, the tanker crew is calculating how far offset from the air refuelling track they need to be, based on the winds at altitude, so that when they roll into a left 180° turn to reverse their direction of flight they will roll out of the turn exactly on track centreline. This is called offset. They also compute how far away from the bomber they need to be when they start their 180° turn so that, when they roll out (hopefully on track centreline), they are also one to three miles in front of the bomber headed down track. This distance is called turn range.

'The plan is that the bomber will hit the ARIP on time, 1,000ft below the tanker, proceed up track towards the ARCP, where the tanker has been orbiting, the tanker will control the length of his orbit legs and his offset from the AR track heading so that he will be at the correct point in space so that when he is at the correctly computed turn range and offset and starts his left 180° turn, he will roll out right in front of the

RIGHT The B-52H's air refuelling schematic shows the route the fuel takes: the receptacle plugs into the air refuel receptacle and then makes its way down the main manifold and into the fuel level control valves of the aircraft's tanks. (USAF)

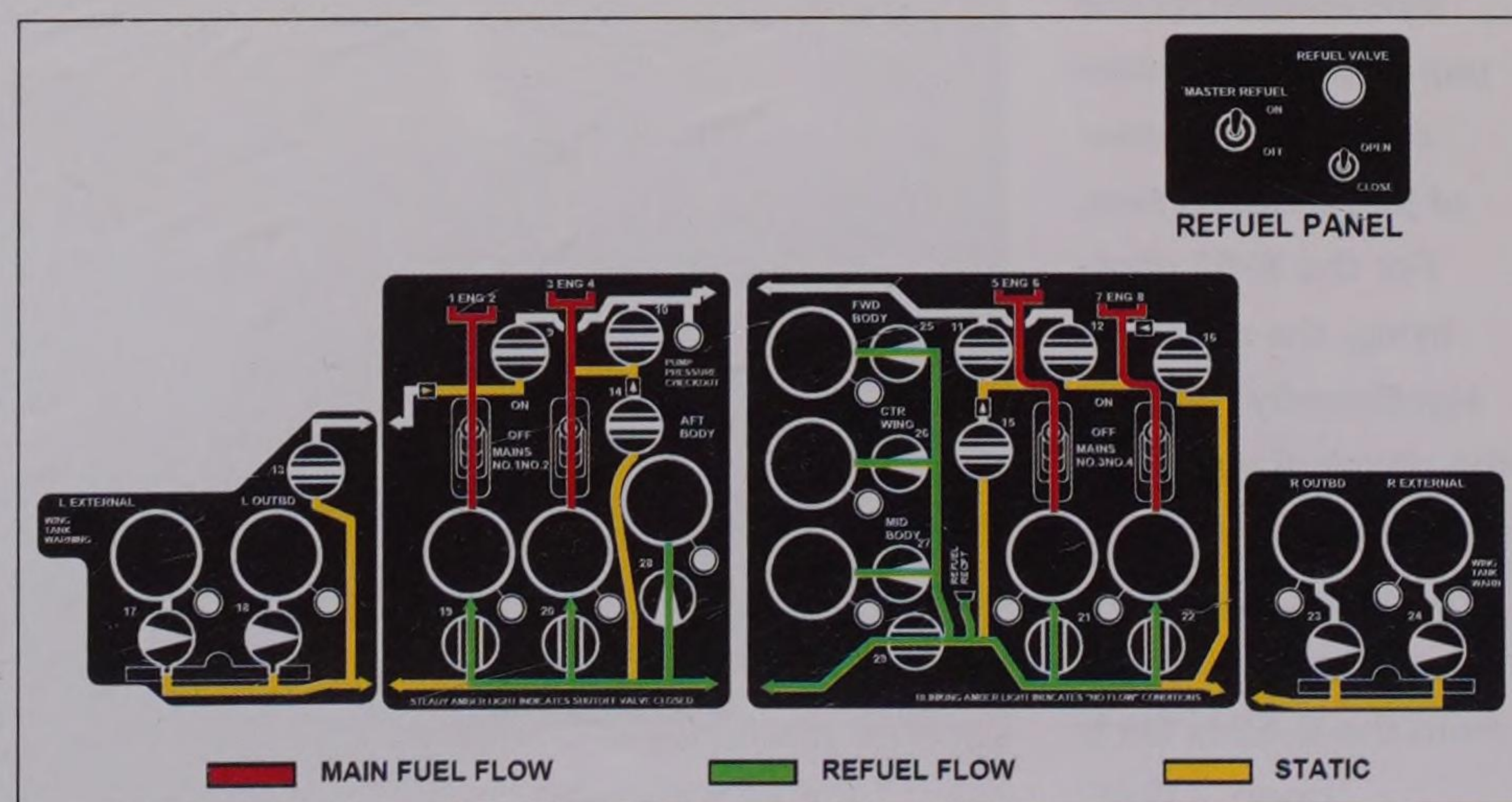
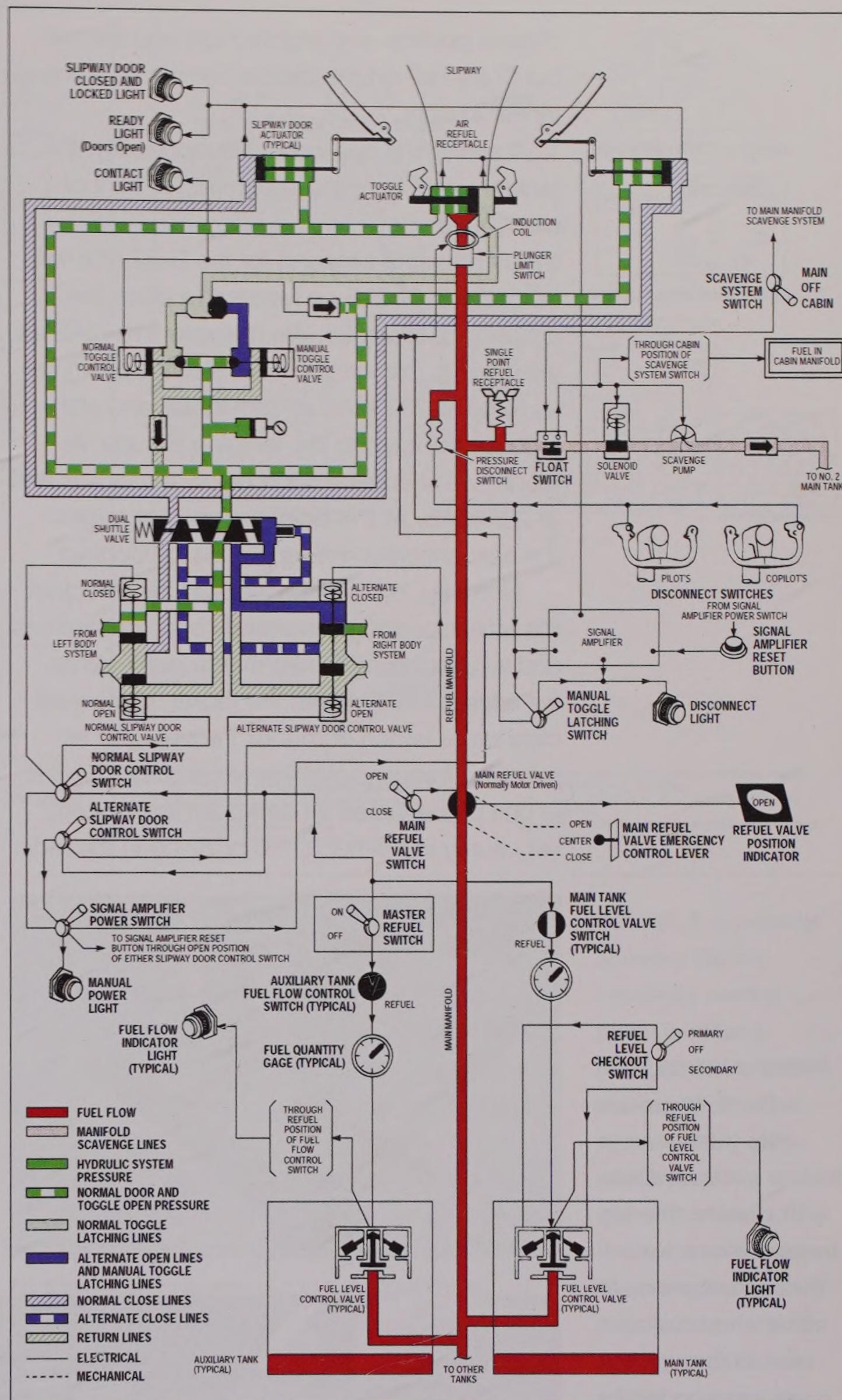
bomber, 1,000ft above him, exactly on time. The bomber navigator also computes turn range and offset, and the navigator and tanker crew compare their data over the radio.

'Fifteen minutes prior to the scheduled ARCT, the time everyone's supposed to arrive at the ARCP, we attempt radio contact with the tanker on the primary air refuelling frequency. We confirm call signs, any changes in estimated time of arrival and our altitudes. In the meantime, we are talking on the other radio with the ARTCC (Air Route Traffic Control Centre, the regional FAA facility that controls air traffic at altitude, radio call sign "Centre") that is controlling us, confirming that we will be using the AR track scheduled for us and who we'll be refuelling with.

'Normally, Centre is now controlling both the bomber and tanker and has a pretty good idea of what's going on. As the two aircraft get closer to each other, Centre can monitor the developing rendezvous on their radar and help out if something goes wrong. Eventually, once we hit the ARIP and proceed down track, Centre will clear us to conduct air refuelling in an altitude block (usually 2,000 or 3,000ft high) under conditions of MARSA (Military Assumes Responsibility for Separation of Aircraft).

'As the two aircraft close on each other, now from approximately opposite directions, the navigator can normally "see" the tanker on his radar scope and can call the turn for the tanker at the desired turn range and offset. As the tanker rolls into his turn, the pilots know from experience where to be looking for the turning tanker (normally at the bomber's 10 to 11

ABOVE The co-pilot controls the air refuelling schedule via his refuel control panel, located at knee height directly in front of him. Main fuel flow to the engines is shown in red, but the refuel routes are shown in green. (USAF)



o'clock position and slightly high) and will call out "Tally Ho" on the radio when we have the tanker in sight.

'If everything has worked out correctly, the tanker will be 3nm (nautical miles) in front of us, 1,000ft above us and doing 275 KIAS, the air refuelling airspeed for the B-52. We will be doing 310 KIAS as we start to close the distance between us. We maintain 310 KIAS as we close to 2nm in trail, start slowing down so as to be at 290 KIAS at 1nm in trail and start a gentle climb up to the tanker's altitude. At 0.5nm we should be 500ft below the tanker and at 285 KIAS. At this point the co-pilot begins the next checklist – "Preparation for Contact".

'Normally, by the time we start this checklist the tanker position has already been determined and we are talking to him on the radio. When we accept MARSA with the tanker, Centre will clear us to switch from their frequency to air refuelling frequency, which we already have set in one of the radios. At that point the co-pilot will usually put either 311.0 or 321.0 in the radio

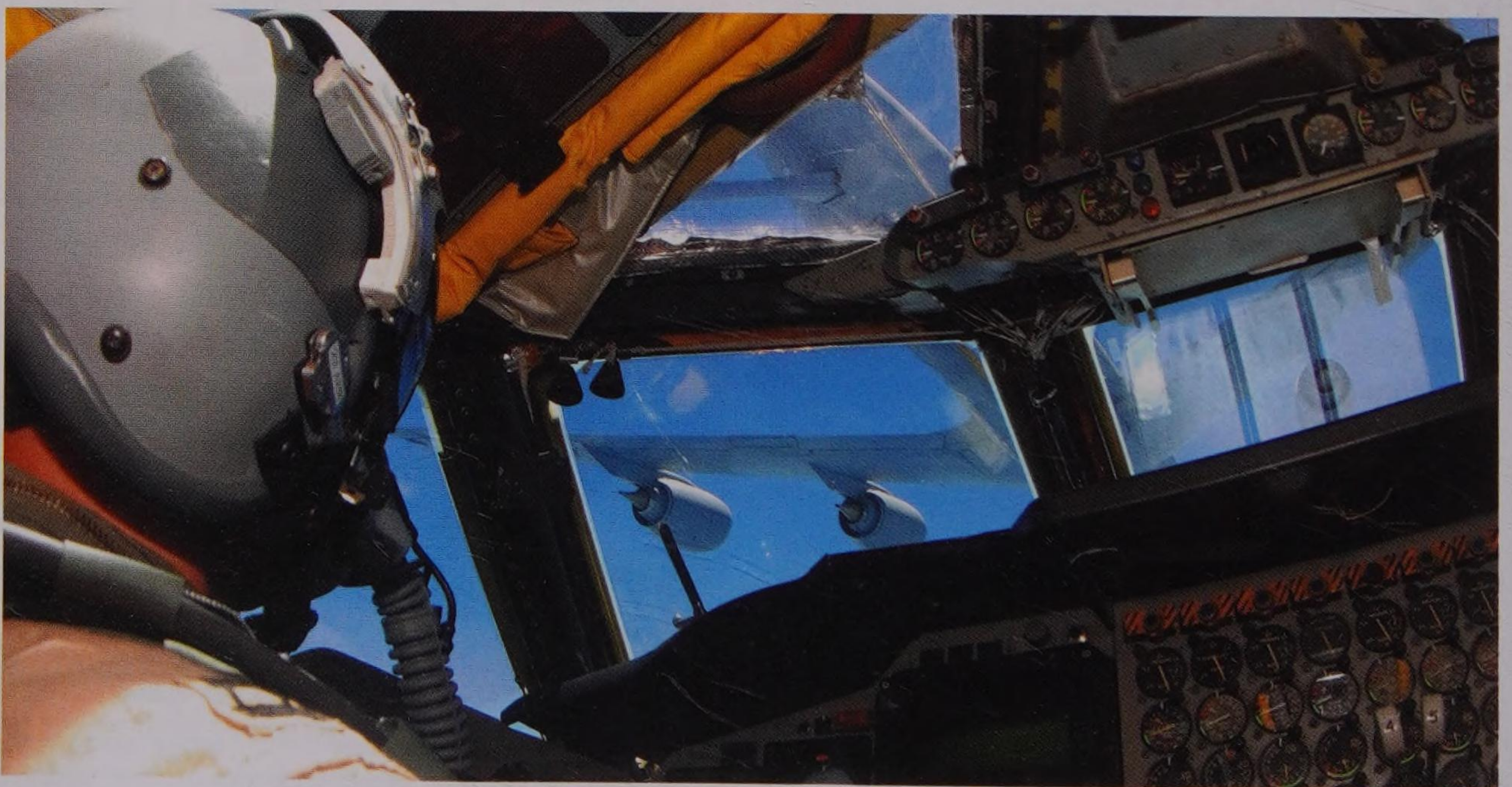
just vacated by Centre, and the pilots will toggle off that radio on their interphone panel so that they don't hear it. Then, while the pilots are busy air refuelling, the EWO can use that radio to call the nearest command post ("Control") and request traffic. That is a requirement of the EWO's that means he is getting a coded message from Control which he copies and decodes. Unless it's something really out of the ordinary the pilots never hear about it and don't really care.

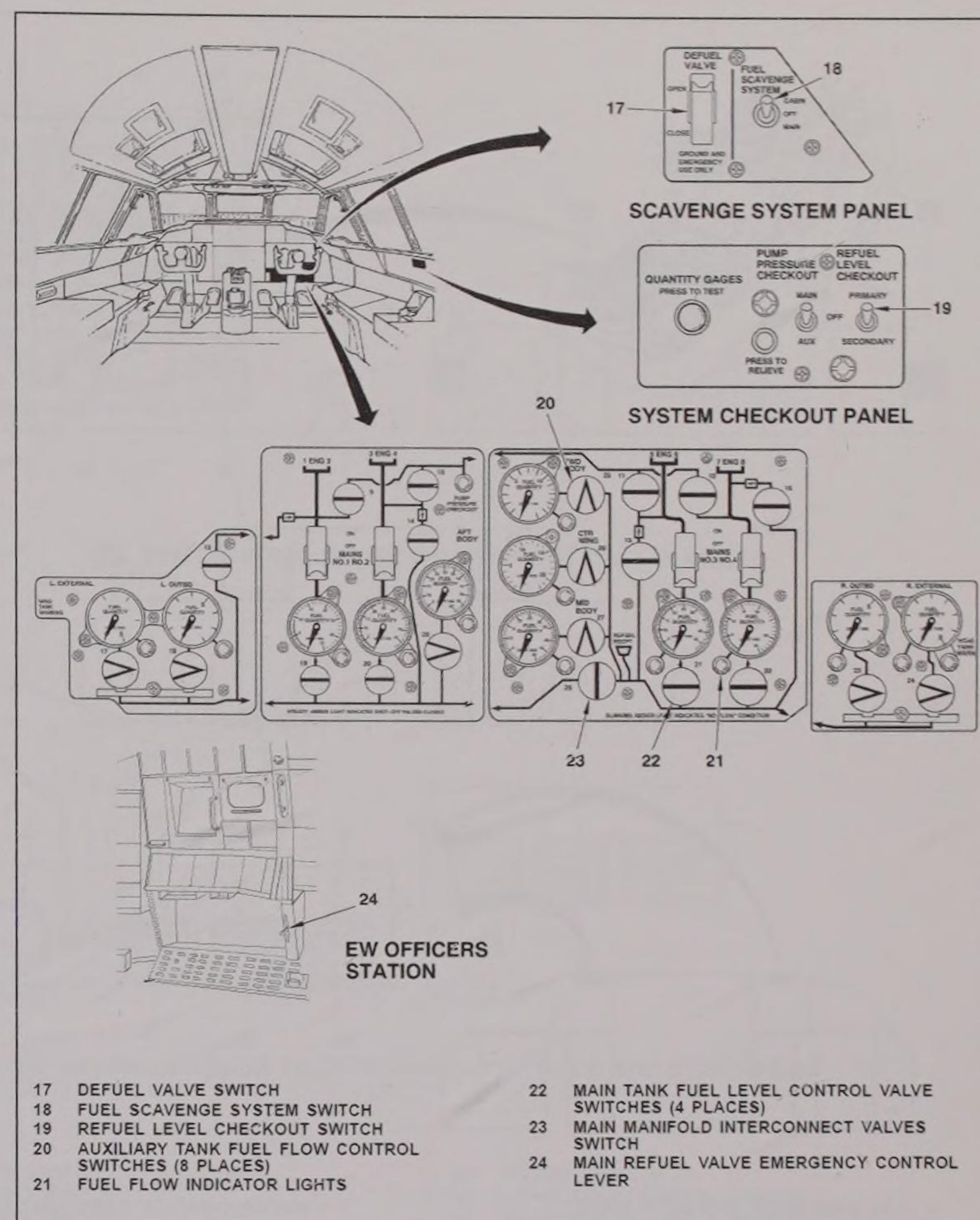
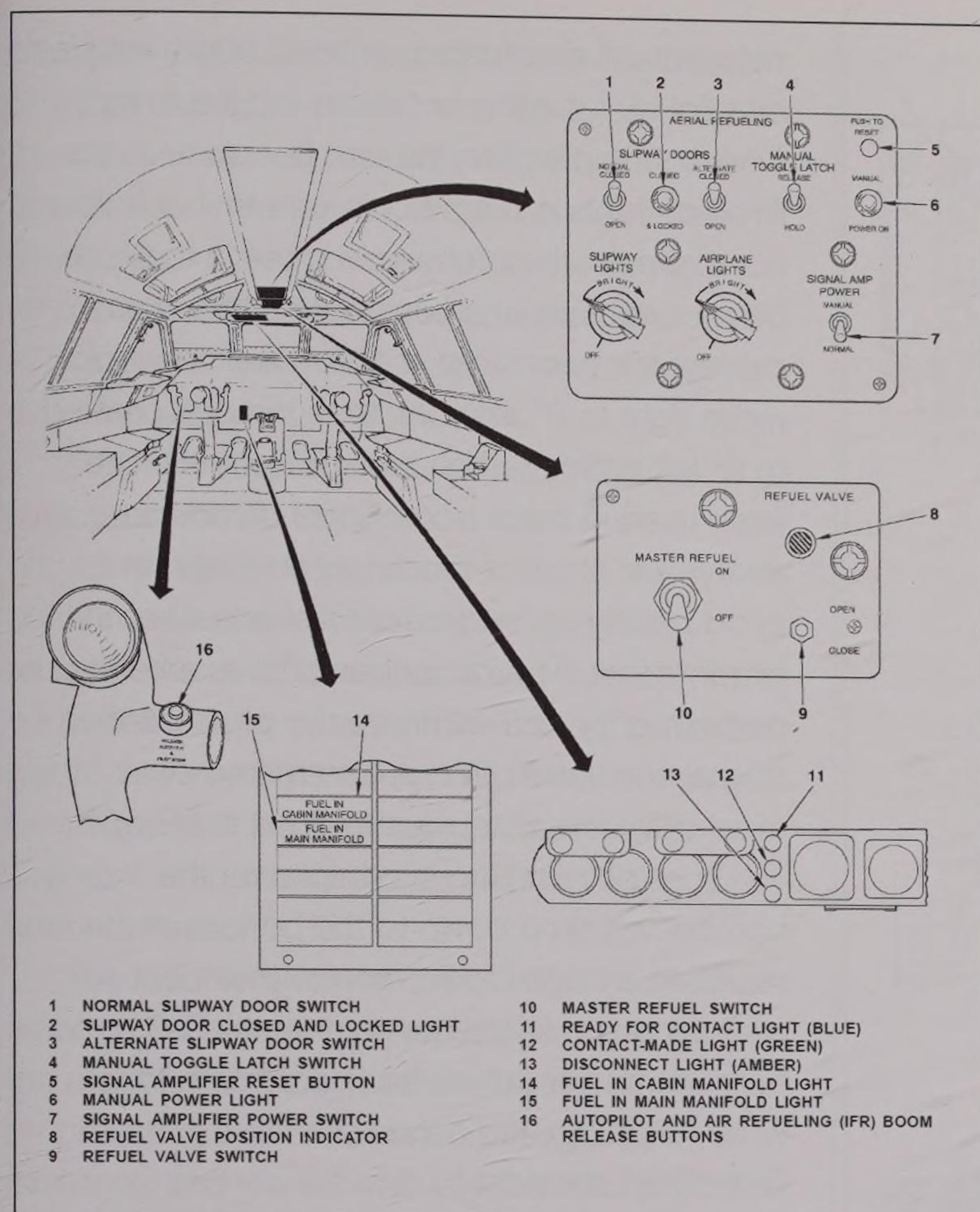
'At 0.5nm in trail, the tanker boom operator usually comes on the tanker radio and begins controlling the final climb into what is called pre-contact position. From then on until in the contact position, the bomber pilots are concentrating on maintaining a smooth, steady rate of closure while remaining directly behind the tanker. There are lights on the bottom of the tanker, controlled by the tanker boom operator, that provide visual signals to the bomber about his position relative to the tanker in both the forward-aft and vertical positions. There are also

RIGHT AND BELOW

The B-52 creeps up to the tanker at a controlled rate of closure. The big bomber's bow wave – the head of pressure that is created as it pushes through the air – can be felt by the refueller as the gap between the two closes to a matter of just a dozen feet.

For the B-52 pilot-flying, the autopilot significantly reduces the physical workload associated with the procedure. As shown here [right], visibility from the B-52 is fairly good. (USAF)





other cues that the bomber pilots can use to help stay properly positioned in the air refuelling envelope, such as antennae on the bottom of the tanker, the position of certain tanker aircraft "parts" in the bomber windows, etc.

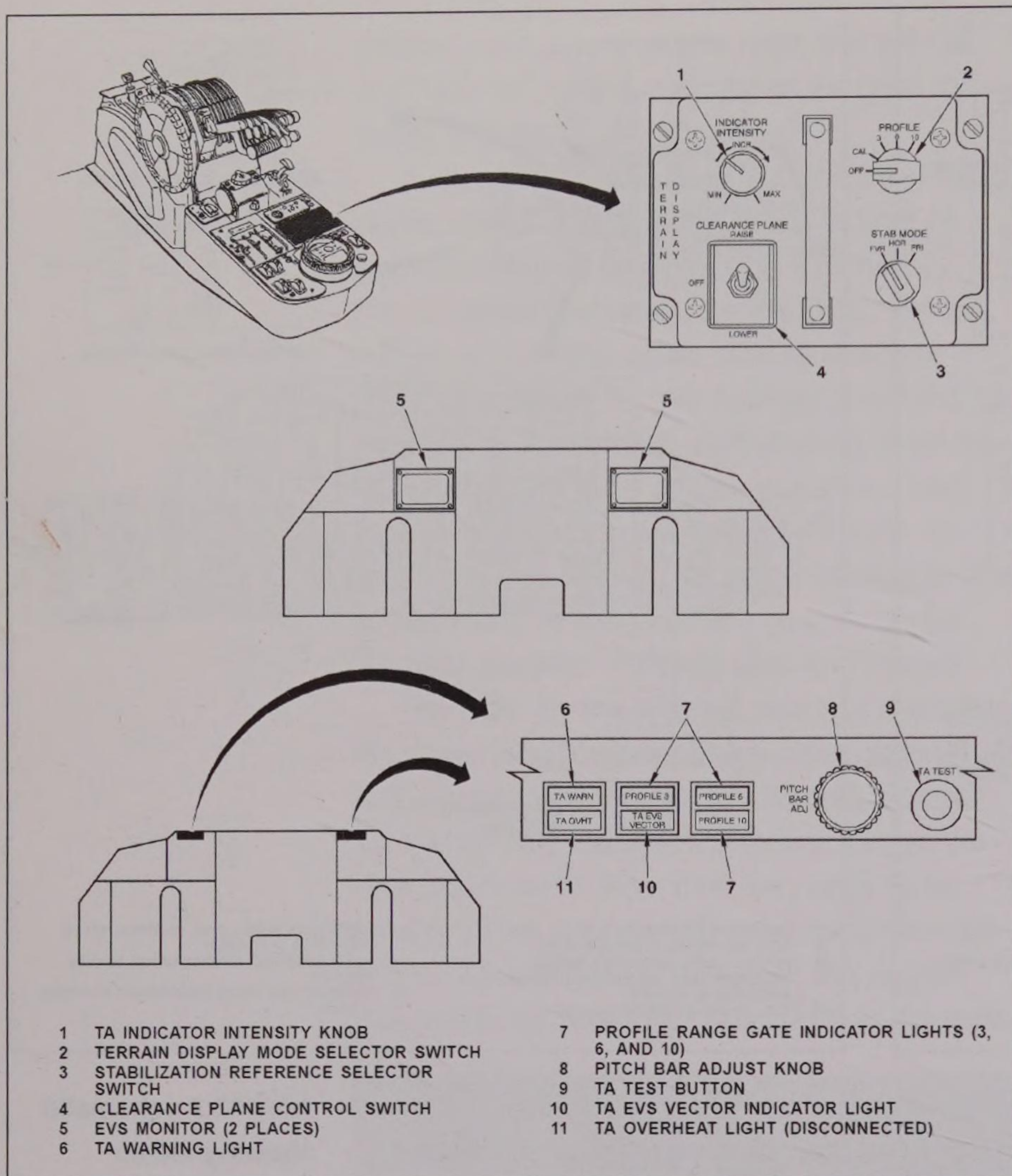
'The air refuelling envelope can be thought of as a "box", the limits or edges of which are defined by the tanker aerial refuelling boom's capabilities in azimuth, elevation and extension/retraction from a central starting point. For the B-52, that starting point is located at the tip of the refuelling boom nozzle when the boom is positioned 30° below horizontal, extended 12ft and centred on the tanker centreline (0° azimuth left or right). This is the position the boom operator flies the boom to when preparing to air refuel, and is called "in the green", since, at this position, the director lights on the bottom of the tanker will have their centred green indicators lit. From this centred green starting point the boom can be flown by the boom operator as far as 10° left and right of tanker centreline in azimuth, up to 10° above and below the 30° normal elevation angle, and extended or retracted up to 6ft from the normal 12ft extension. This creates a "box" 20° wide, 20° deep and 12ft long, centred on the normal boom nozzle position.

'The bomber pilots stop their closure on the tanker when they are approximately 50ft behind and slightly below it. This is the pre-contact position. At this point the bomber will call, "Roma 35, Griff 52 Heavy (or whatever our call signs are), stabilised pre-contact, ready." The tanker boom operator will call, "Griff 52 Heavy, Roma 35, cleared to contact position." The bomber will add a slight amount of thrust and climb slowly up and forward into contact with the tanker boom. As the boom bottoms out in the receptacle and the toggles latch the boom into position, the "Contact" checklist is accomplished by the bomber pilot not flying the aircraft.

'During a typical training mission air refuelling, where there is only a token on-load by the bomber, the co-pilot will just feed the on-loaded fuel directly into the four main engine fuel tanks. However, for a larger on-load, the co-pilot will adjust the main and auxiliary tank control switches as necessary during the course of the on-load to comply with the appropriate "Air Refuelling Procedure" checklist in his abbreviated flight crew checklists, based on the external weapons configuration and total fuel on board.

'The pilots may spend some AR track time practising autopilot off air refuelling, tanker

ABOVE A schematic showing the air refuelling control panel locations point to the co-pilot as having principal responsibility for controlling this crucial element of flight. The B-52 is sensitive to CG changes, so the co-pilot regularly fills in a 'Form 200', on which he notes down fuel quantities and balances. (USAF)



autopilot off air refuelling, manual boom latching, co-pilot air refuelling or “demo-ing the limits”, wherein the pilot flies the bomber close to the limits of the boom envelope, one limit at a time. For example, the pilot would close in to 8ft of boom extension and back out to 16ft, then move back to centred at 12ft. Then he would move right to 8° azimuth, then through centred to 8° left azimuth, then back to centred. The limits used in these boom limits demos are always just short of the actual envelope limits, to avoid getting an inadvertent disconnect at the extreme limit. This “limits demo” is required to be performed by all B-52 instructor pilots on their annual check-ride, and is considered one of the most difficult manoeuvres to do in the B-52.

‘Once air refuelling is completed, the bomber will drop down to the bottom of the air refuelling altitude block, receive their post-AR clearance and frequency to contact Centre on from the tanker (which had coordinated that while refuelling) and accomplish the “Post Air Refuelling” checklist.’

Low-level bomb drop

‘The entry altimeter for the route, received from Centre as we’re cleared into the route, is set as we descend through 18,000ft MSL; the terrain avoidance (TA) equipment is turned on and the clearance plane (the height the TA equipment should fly us above the ground) and radar altimeters are initially set to 800ft AGL. Once we pass the “Start VFR/TA Point” on the route, we slowly descend to 800ft AGL and I advise the gunner that we are level at TA altitude. IR routes are classified as either flat and rolling or mountainous (or possibly both, with legs in each category), and the height we are allowed to fly above the ground – called the

LEFT During the Cold War it was believed that to penetrate the dense defences of the Soviet Union the only way to survive was to fly beneath radar coverage. To this end, low-level penetration systems were developed to enable the jet to mask itself behind terrain whilst avoiding flying into the ground. Here, two Barksdale B-52Hs descend gently as they begin their low-level ingress to the target. (USAF)

ABOVE With the low-level portion of the mission about to get under way, the terrain avoidance system is activated. Six eye-level warning lights are located just below the coaming above the centre instrument panel, indicating the range gate for the TA profile in use, a general TA warning, and the EVS vector indicator. (USAF)



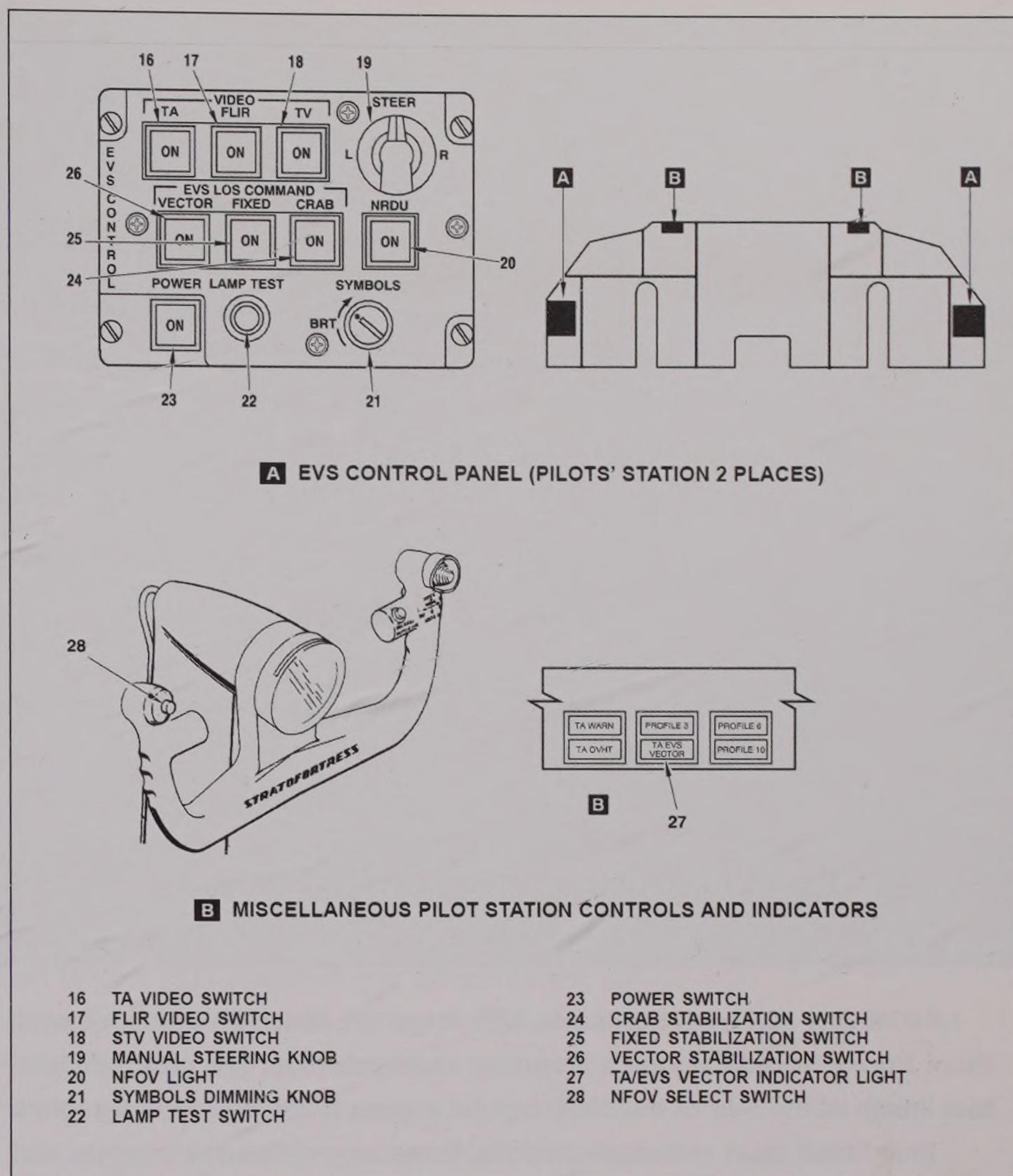
clearance plane – on training missions is based on which category route we’re flying, as well as the qualifications of the crew and whether it is day or night. The lowest clearance planes are used on a flat and rolling route in the day by an experienced crew, and the highest are used at night on a mountainous route with a less experienced crew.

‘The next several checklist steps involve evaluating the TA system to ensure it is providing reliable information. Every IR route contains a feature at the beginning of the route that is used to calibrate and evaluate the equipment. On a mountainous route this feature will be a distinctive peak or hilltop with a known elevation; on a flat and rolling route it will be a segment of the route that is relatively flat and of known elevation.

‘The initial level-off will be at 800ft above the feature and altitude hold will be engaged on the autopilot. By this time the TA system will be providing a terrain trace on the pilot’s EVS monitors, and we will evaluate the reliability of the trace as compared to what we actually see outside the window. The navigator states the terrain elevation and we compare that, plus our radar altimeter reading, with what our pressure altimeters are reading – they should be close.

‘Next, the three stabilisation modes of the TA equipment are compared. In FVR (flight vector reference) mode, the clearance plane is maintained parallel to the flight path of the aircraft. In HOR (horizontal) mode, the clearance plane is maintained horizontal within the pitch and roll limits of the vertical gyro. In FRL (fuselage reference line) mode, the clearance plane is maintained at a preset angle that is nearly parallel to the longitudinal axis of the aircraft. The comparison method differs depending on whether the check is accomplished on a flat and rolling segment or on a peak, but the effect is the same – the pilots and nav team are able to determine the reliability of each mode and whether or not there are any errors in the system, and if so, of what magnitude.

‘Upon completion of this step, autopilot “altitude hold” mode is disengaged and “low level” mode is engaged. The low level mode of the autopilot can be thought of as power steering for the aircraft. This mode, and the



similar “aerial refuel” mode, are designed to substantially reduce the loads imposed on the aircraft during these two phases of flight, as well as reducing pilot fatigue. When using these modes, the pilot flies the aircraft through the autopilot by control column inputs in the same manner that he flies without the autopilot, except that control column forces are considerably reduced.

‘Following this, “Profile 3” is selected. There are four TA profile settings available (3, 6, 10 and Cal), three of which (3, 6 and 10) would normally be used while flying TA, with Pro Cal being used for calibration purposes. The three normal positions differ only in the distance the TA system “looks” ahead of the aircraft – Pro 3 provides a silhouette outline display on the pilots’ EVS monitors of the highest terrain between the equipment minimum range and 3nm ahead of the aircraft, Pro 6 reaches out to 6nm and Pro 10 to 10nm. Normally, Pro 3 is used.

‘Next, the clearance plane and radar altimeters are set to the designated clearance plane setting for the current leg of the route.

ABOVE The EVS controls are found on the centre control panel. The field of view switch is thumb operated and located on the pilots’ control yokes. (USAF)



ABOVE A B-52H from Barksdale AFB drops live Mk82AIR ordnance over Point Bravo, Nevada, during a firepower demonstration. The little 'ballutes' that inflate at the rear of the 500lb bombs ensure that the B-52 can escape their lethal blast radius. Meanwhile, flares are released to confuse and distract any heat-seeking missiles fired at the aircraft during this vulnerable phase of flight. (USAF)



RIGHT For nuclear strike missions, nuclear flash blindness goggles were developed for B-52 pilots. These once-only use goggles protect the crew from the nuclear flash, although the aircraft is also equipped with low-tech flash curtains that would be lowered prior to target ingress. (USAF)

Finally, any tilt errors in the FRL stabilisation mode are compensated for and a similar compensation is accomplished for FVR mode. Normally FVR mode is left selected, as it is the most reliable.

'Once the entire TA compensation check is completed, the crew concentrates on flying the route safely and getting the bombs on the target. Of course, in peacetime actual live bombs are rarely dropped during training missions. For a conventional strike training mission, the aircraft may have BDUs (bomb dummy units) loaded, which are concrete-filled bombs that mimic the size, shape and ballistics of actual bombs. Or there may be small 25lb practice bombs which contain a small spotting charge that allows spotters on the ground to determine the impact of the bomb.

'However, for nuclear strike training missions the release of a weapon is simulated through the use of a tone system whereby a pure tone is broadcast over the aircraft radios on the RBS (radar bomb scoring) site's scoring frequency. The RBS site has equipment that locks on to the tone and tracks the aircraft as it heads towards the target. The tone system is tied into the bombing computers, so that at the precise moment that the weapon would have been released, the tone cuts off. This provides the

RBS site with a precise position of the bomber at weapon release. This information, along with the weapon ballistics and other information that we provide the site, allows them to plot a post-release trajectory for the weapon and determine our bombing accuracy.

‘As we fly through the route, the pilots follow the heading marker on their EVS monitor displays which is generated by the navigation computers. During low level, bank angles are limited to 12° so as not to place the downside wing tip too close to the ground during turns, and also so as not to disrupt the TA trace display, which is only roll-compensated for bank angles up to 12°. The route corridor is generally four miles wide, and as long as the aircraft stays in the corridor the pilots are free to manoeuvre the jet to take advantage of terrain masking and other tactical considerations. The pilots follow the route navigation provided by the navigator on their low-level route map, cross-checking headings, altitudes, obstructions on the leg, etc.

‘As the jet approaches the RBS site and target area, radio contact is made with the site. The nav team runs their weapon delivery checklists, with the pilots accomplishing any items involving them. The aircraft radios are set to the RBS site scoring frequency. At the bomb run IP (initial point), the co-pilot calls the RBS site with an “IP inbound” call. Normally, one pilot flies the jet and concentrates on maintaining bomb run heading, while the other pilot “flies the throttles”, concentrating on maintaining the airspeed the navigator has computed will be necessary for an on-time release. Inside of 120 TTG (“time to go”, ie to release of bomb or bombs, in seconds), things really start to get busy, especially for the nav team.

‘At 20 TTG the tone comes on; at 10 TTG the bomb doors are opened automatically by the bombing computers. At 0 TTG the tone cuts automatically, the co-pilot radios the RBS site with a “Bombs away” call, the nav team gathers and records post-release information and, if there is a subsequent release on this run, the process starts over again.

‘Often a low level will have either more than one target area along the route, or there will be a racetrack located at the target area which provides the crew an opportunity to practise bombing more than once by flying around the

racetrack and coming across the target area a second or third time. Racetracks are normally 30 minutes long, and other bombers may be scheduled across the target area while we are on the racetrack.

‘After all bombing is complete, the crew will climb out of the low level route and re-enter the Federal airspace system. Upon starting our climb out, the “Climb After Low Level” checklist is accomplished.’

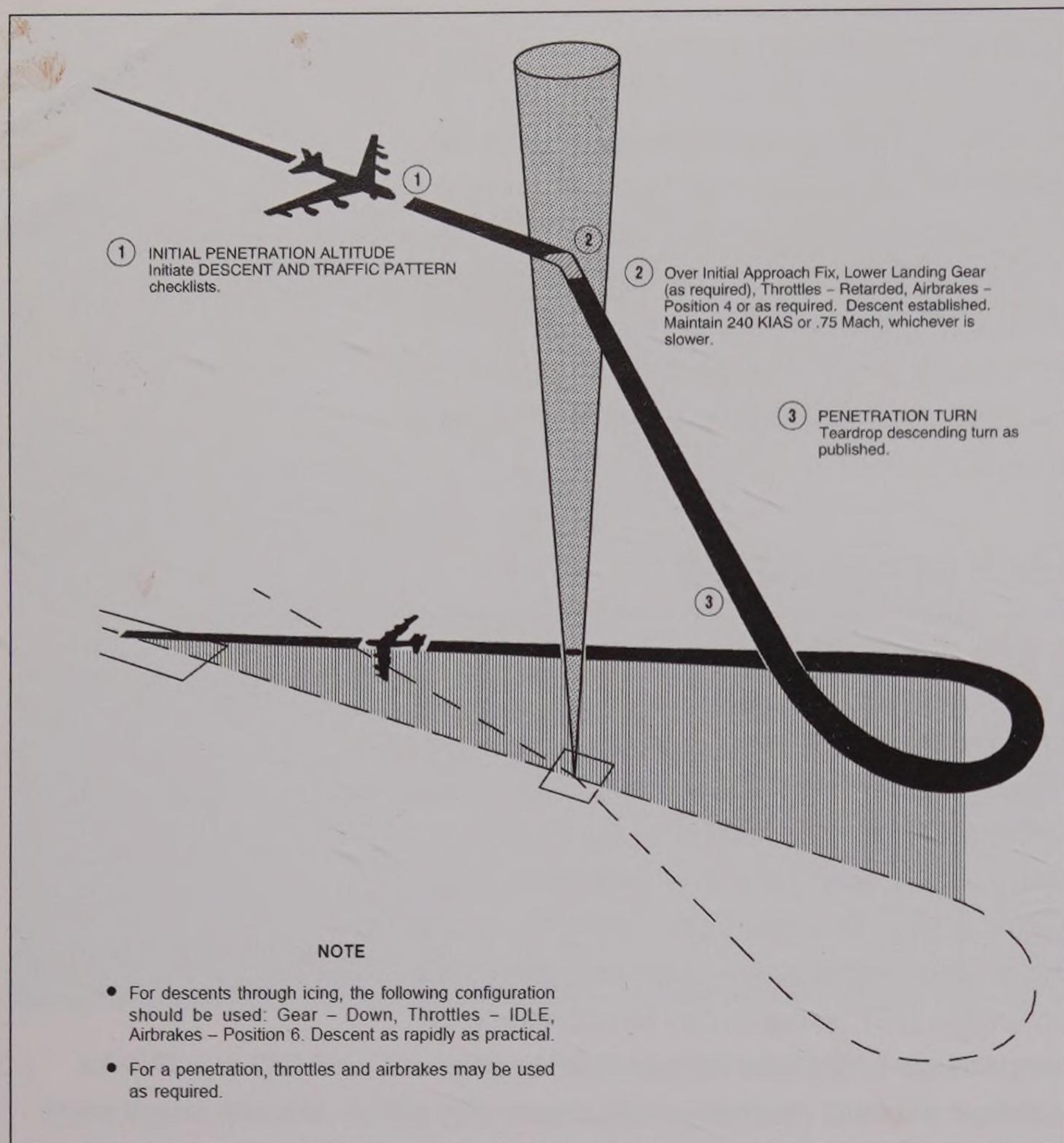
Return to base

‘Once air refuelling and low level have been completed, there is normally not much more for the pilots to do until returning to base. At some point an Engine Condition Data Sheet will be accomplished by the co-pilot. This involves setting the engine throttles, one pair at a time, to a pre-computed EPR, letting the engines stabilise, and then collecting data on engine EGT (exhaust gas temperature), oil temperature and pressure, fuel flow, engine vibration etc, and recording it on a form that will be used after flight by maintenance personnel to try to predict which engines might be headed towards failure.

‘Other activities which might occur could be a navigation leg, a fighter intercept exercise, a fire-out for the tail guns, an initial buffet demonstration, etc. [Initial buffet is defined as the point at which airflow starts to separate from the wing. Causing a light tremble in most aircraft, it is a precursor to a stall.] Mainly, however, it’s a chance for the pilots to engage the autopilot, work on completing mission paperwork, and eat our box lunches that we ordered the day before.

‘Once we’re headed back home, it’s time to start thinking about our descent and traffic pattern activity. Depending on how much flying time the Wing has left to burn and the needs of the pilot team, the mission may be scheduled for anywhere from zero to one hour or more of transition time – time the pilots get to spend practising approaches and landings, and which the rest of the crew learns to despise, since they are pretty much uninvolved in the happenings in “the front office” and will have to sit through multiple “bounce and goes”.

‘On mission planning day we would have



**ABOVE The B-52's
typical return to base
will use a high-altitude
initial approach fix
(IAF), as shown here.
(USAF)**

discussed what the pilots plan to do with whatever transition time was scheduled for the flight. Normally, an en-route descent to intercept the final approach portion of a published approach is accomplished; very rarely will an entire high altitude published approach starting at the IAF (initial approach fix) be flown.

'Approximately 100 miles out from home the pilots will coordinate with Centre on their desired transition and approach. The planned approach will be reviewed by the crew and the co-pilot will call the home station to obtain landing weather.

'Approaching 60 miles out, the "Descent" checklist will be accomplished. The pilots will turn their EVS power back on if it has been turned off (we would sometimes turn the system off and stow the turrets during long cruise legs to lessen the noise level) and select the sensor (FLIR or STV) with the best display and vector stabilisation.

'The pilot and nav teams then go over the penetration and first planned approach. The pilot flying the approach will brief the rest of the crew on our descent rate, MDA/DH/VDP (minimum descent altitude/decision

height/visual descent point) and our missed approach procedures. The pilot flying the approach will set his radar altimeter to the HAA/HAT (height above aerodrome/height above touchdown) for the approach we're flying, and the other pilot will set his radar altimeter to 100ft above HAA/HAT.

'The co-pilot will compute the aircraft gross weight and best flare speed for airbrakes position 4. He will then make sure the best flare speed indicator ring, which rotates around the total fuel quantity gauge, is set so that the aircraft operating weight plus expendable stores is at the zero point on the gauge. This way, the gauge needle will point to the current aircraft gross weight and corresponding best flare speed for that weight at airbrakes 4. The navigator uses his own table of aircraft weights and best flare speeds to cross-check the co-pilot's numbers.

'Also, the thrust gate setting will be computed and set. The fuel panel is configured for the descent and checked, the CG/FLAS is set, and the landing, taxi and crosswind landing lights are turned on. Finally, as we descend through transition altitude (normally 18,000ft MSL), the local area altimeter is set.

'Normally Centre will tell us when to begin our descent and give us any altitude restrictions they want us to make along the way. After we've descended into the low structure and are within approximately 30nm of the base, Centre will hand us off to Approach Control. Approach Control will continue to vector us to intercept the final approach portion of our requested approach as they descend us on down to our final approach course intercept altitude and sequence us on to final with other traffic they may be working.

'As we prepare to intercept final, the pilots will begin the "Traffic Pattern" checklist. We make sure the appropriate navigation aids (normally the TACAN channel and localiser frequency for the approach being flown) are tuned and identified, and that the designated final approach course is set in our HSIs. Radar altimeters are already set from the previous checklist. The pilot flying the approach will allow the aircraft to decelerate to 220 KIAS during vectors to final and request lowering of the flaps. The other pilot will place the flap handle

RIGHT AND CENTRE During the return to base, the co-pilot will make final use of the FLAS/CG (centre of gravity/fuel level advisory system).

This is particularly important if any stores need to be jettisoned prior to landing, as the B-52 has specific CG and airspeed limitations for weapons jettison. (USAF)

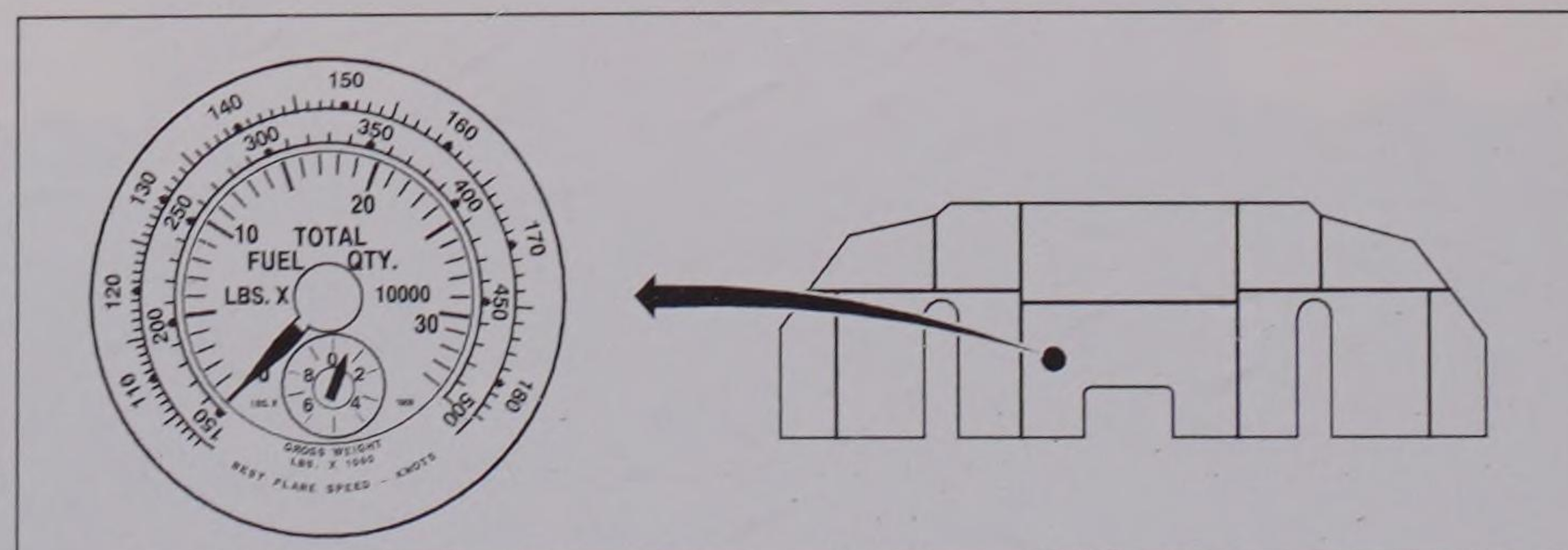
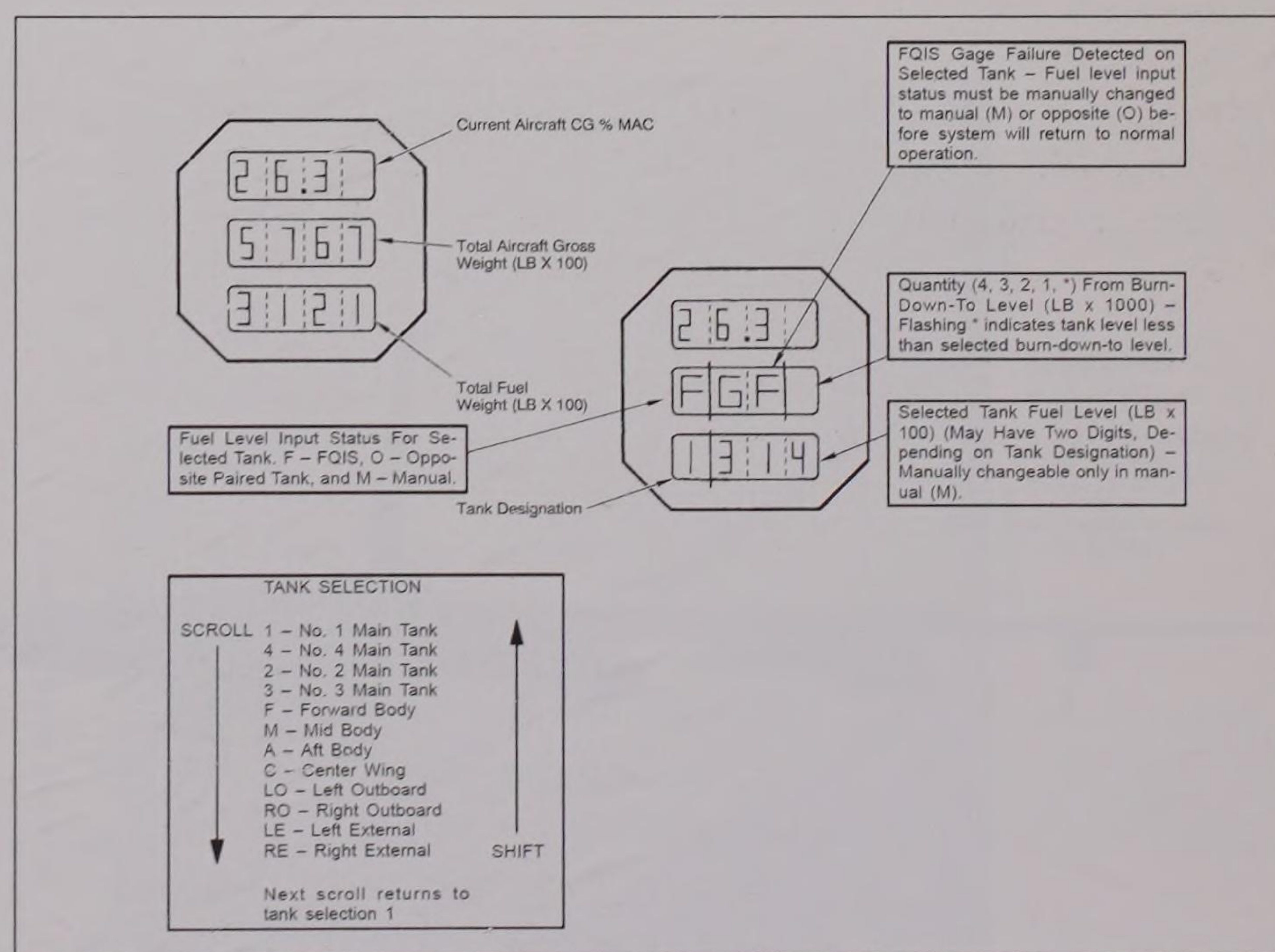
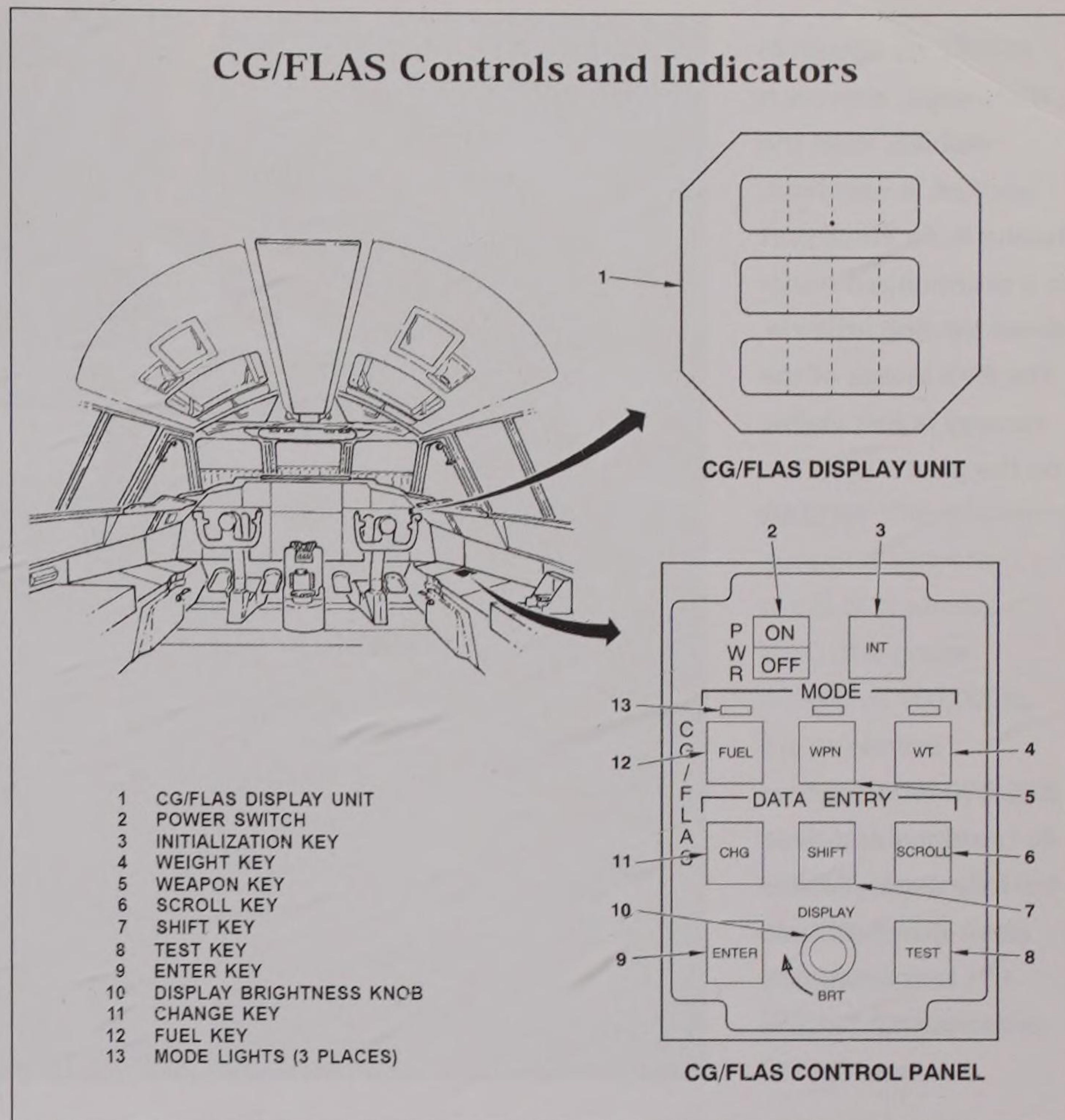
in the "down" position and note that both flaps extend simultaneously, and within ten seconds of positioning the handle. He will call out "Flaps 50%" and "Flaps full down".

The pilot flying the approach will continue to allow the aircraft to decelerate to reach best flare + 30 KIAS and will maintain this airspeed as the aircraft is vectored to final. The co-pilot will note the fuel level in main tanks 1 and 4 – if the fuel level is above the green band* valves 9, 10, 11 and 12 are closed. If either main No1 or No4 are indicating in the green band, these valves are opened. The co-pilot may also use auxiliary tank fuel to replenish mains 1 and 4 and to balance the fuel levels in the main tanks. After this, the pilot not flying the approach reads off the current fuel quantity for the navigator and reads out the best flare speed indicator ring to the navigator, who will cross-check the best flare speed. The thrust gate will also be rechecked – a quick check to set it without having to refer to a chart is to advance throttles 4 and 5 to obtain a 5,000pph (pounds per hour) increase in total fuel flow, and then adjust the thrust gate to that throttle position.

At the appropriate point in the approach, the pilot will call for the landing gear to be lowered. The other pilot will place the landing gear lever in the "down" position and note that the gear warning light goes out and that all six gear indicate down and locked. The anti-skid indicator panel is checked, and the crosswind crab is set using the crosswind

* A green-painted band on main tanks 1 and 4 fuel gauges, covering a tank quantity from 0 to 8,850lb of fuel. This has to do with outboard wing tank fuel usage and potential airspeed limitations due to wing flutter.

RIGHT The co-pilot is also responsible for computing and setting the best flare speed indicator, which indicates the best flare speed, gross weight and fuel quantity. (USAF)



RIGHT As shown in this image, approach visibility from the cockpit is excellent, thanks in no small part to a pronounced nose-down landing attitude. The EVS image of the runway is just visible on the pilot's monitor. (USAF)



BELOW With spoilers raised and flaps fully deployed, the nose-down attitude is dramatically demonstrated in this image. (USAF)



crab knob on the centre console. The knob is then checked down.

'On base leg the aircraft is slowed to best flare + 20kt, and on final best flare + 10 KIAS is flown. Once on final, maintaining BF + 10 and configured with gear, flaps and airbrakes 4, and trimmed for zero stick force, the pilot not flying notes the stabiliser trim setting and calls out a value two units in the nose-up direction as the target trim value (ie if stabiliser trim on final is reading 4.5 units of nose-down trim, the target trim value would be 2.5 nose-down). On a B-52H the target trim value should be between 1.0 and 3.0 units of nose-down trim – if it's not, either the pilot flying the approach hasn't trimmed the aircraft properly or something is off with the aircraft configuration. Finally, a quick landing check is accomplished.

'In addition to accomplishing this checklist, as an instructor pilot I would also brief the pilots to use smooth power applications, avoid compressor stalls (and what to do if we got one anyway), follow all flight manual procedures, what we would do in the event of an unplanned drag chute deployment, proper use of airbrakes and stabiliser trim, proper transfer of aircraft control and that we would use all eight engines in the event of an unplanned go-around.

'There were some pattern activities that required an IP to be in one of the pilot's seats – if I was flying as an extra crew member I would have already gotten into the appropriate seat (probably before we started our en-route descent) so that the other pilot who needed the activity requiring an IP in the seat would be good to go. However, when I flew with my own crew such a seat-swap was not necessary. Sometimes when I flew as an extra crew member we would end up having to do a double seat-swap on the downwind leg of the traffic pattern so that we could switch, for example, from me in the left seat and the co-pilot in the right seat to me in the right seat and the pilot in the left seat. Double seat-swaps always reminded me of a Chinese fire drill and were among the more challenging pattern activities that we did.

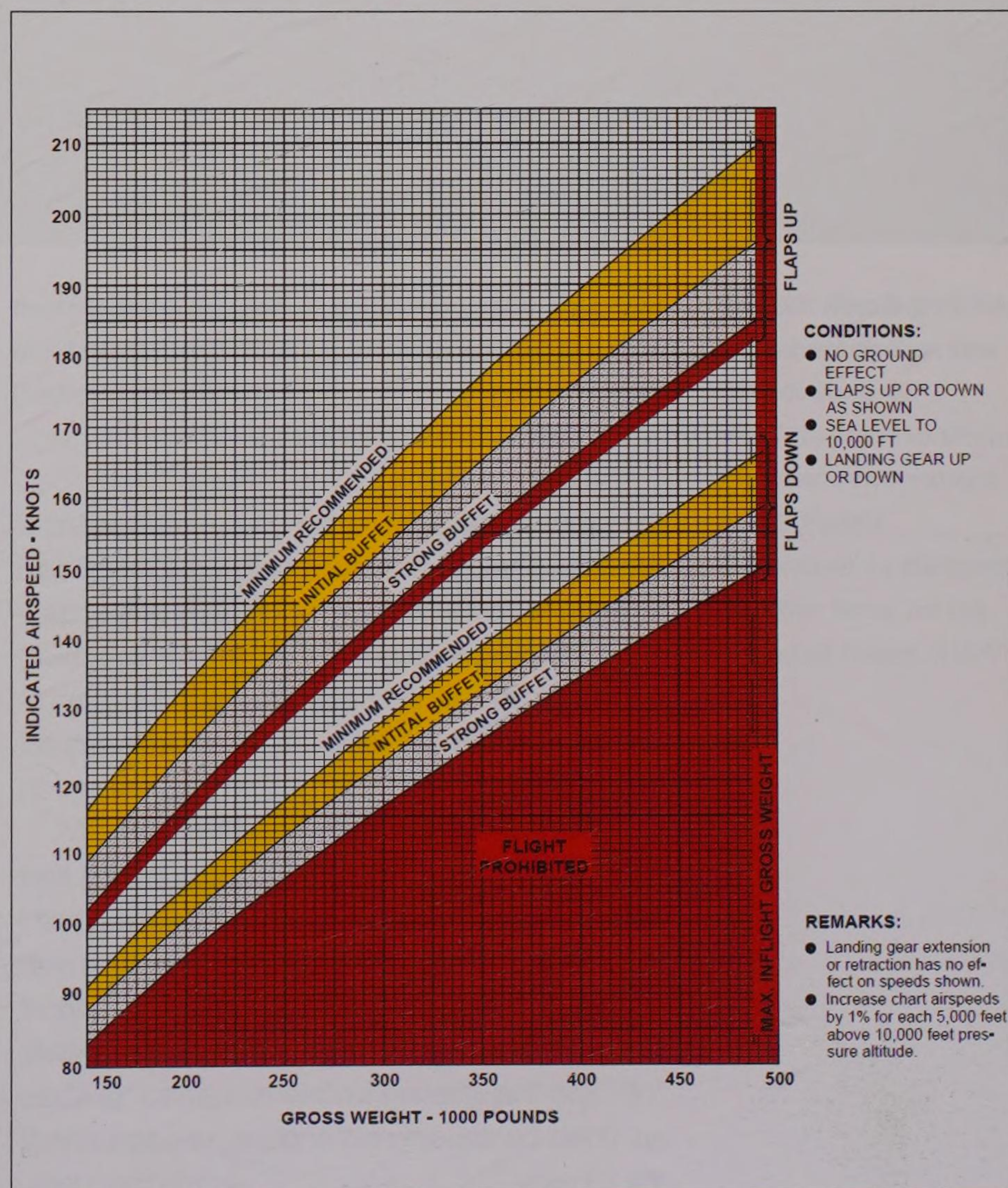
'Once Approach Control have us vectored on to final, they clear us for the approach and hand us off to Tower. We contact Tower and advise them of our intentions (full stop, low

approach, touch and go, back to Approach or request closed, etc). Tower gives us the latest altimeter setting, clears us for our requested action and advises us of other traffic in the pattern. If we are flying an instrument approach, the pilot flying the approach concentrates on his instruments (ILS or localiser) while the other pilot monitors airspeed and altitude and clears outside for other traffic and birds.

'If we are flying a visual approach, we usually set in the ILS anyway and use it as a backup for the visual. Assuming we plan to full stop, as we come in over the runway overrun the pilot retards the throttles so as to cross the runway threshold at best flare speed. The aircraft tends to pitch up as it enters ground effect, which helps to flare the aircraft for landing. A couple of units of nose-up trim and some back-pressure on the control column should result in a smooth, rear-gear-first touchdown on runway centreline in the first 2,000ft of runway.

'After touchdown, the "Landing" checklist is accomplished. As soon as we are definitely on

BELOW The minimum airspeed chart for the B-52H shows that, at a gross weight of 150,000lb, the minimum recommended airspeed is around 95 KIAS (knots indicated airspeed) with flaps deployed, and 122 KIAS with flaps up. (USAF)





6

ABOVE Below 135 KIAS, the drag chute is deployed to help slow the aircraft and reduce brake wear. Here, a B-52H lands at Minot AFB, North Dakota, in June 2011. (USAF)

the ground, the airbrakes are fully extended and the drag chute is deployed below 135 KIAS (the maximum chute deployment speed) to help us slow down. The pilot who flew the approach will gently apply the brakes to check for proper operation and then apply them as necessary to slow to taxi speed.

'The pilot checks the hydraulic panel to confirm all hydraulic pump out lights are off and centres the crosswind crab (if used) by means of the crosswind crab centring button once we are slowed to a safe taxi speed and about to turn off the runway. Starter switches are turned "off" and the steering ratio is moved to "taxi" as we finish our landing roll and prepare to turn off the runway.'

Taxi and shutdown

'As we finish our landing roll, Tower will clear us off the runway and tell us to contact Ground Control when off. Ground will tell us to taxi to parking.

'At some point during the descent and approach, the EWO would have used one of the radios to call Control (Command Post) and passed on our maintenance codes and received any changes to our planned transition time as well as our parking spot. Once Ground clears us to taxi to parking, the EW will come on the interphone and tell the pilots which parking spot to taxi to. As we make the first 90° turn off of the runway, the pilot will run up engines 4 and 5 briefly to help keep the drag chute inflated as the co-pilot starts the "After Landing" checklist.

'After we're clear of the runway and with engines 4 and 5 run-up to keep the chute inflated (so that it doesn't wrap around the



turret or horizontal stabiliser), the co-pilot will jettison the drag chute on the taxiway and then return the control handle to "locked". The pilot team will "safe" their ejection seats and then turn switches and systems off that are no longer needed for taxi.

'The classified IFF Mode 4 code will then be erased. Next, the outboard engines are shut down, since their thrust, and the electrical power from the generators on engines 1 and 7, are not necessary for taxi. Usually engine No6 is also shut down at this time, for the same reason.

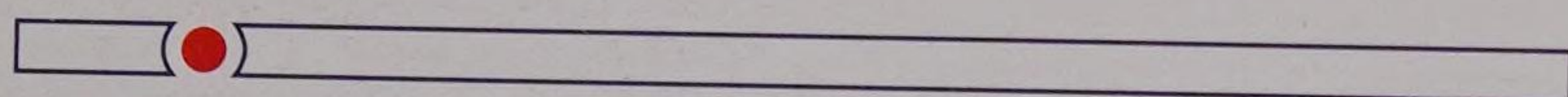
'Prior to shutting down any engine it has to idle for two minutes. Then the throttle is advanced to 75% rpm for between 15 and 30 seconds, to scavenge the engine oil and prevent fuel from accumulating underneath the engine after shutdown. Following shutdown of these engines, the co-pilot closes any fuel valves not required to keep feeding the remaining operating engines.

'A sliding window is opened to relieve cabin pressure and the bomb doors are opened. If we carried any internal weapons on the sortie, the navigator will have to leave his seat and crawl back into the bomb bay to visually check that there are no bombs hung up in the racks or resting on the doors. This may be accomplished while still in flight (provided we're below 10,000ft MSL, since we'll have to depressurise the aircraft) or once we're back on the ground. Either way, it's a thankless task that can be potentially dangerous.

'We will continue to taxi towards our final parking spot. More than likely our crew chief will have us stop on the centreline of the mass parking area and we'll shut down there. The maintenance folks will then take charge of the airplane and be responsible for pushing the jet back into its actual parking spot, once we get to where the crew chief wants us to stop.'

ABOVE Taxiing to dispersal, the first of six B-52 Stratofortresses arrive for their commitment to US Pacific Command's rotational bomber force on the island of Guam. (USAF)

Flying the Stratofortress: the gunner's view



While the B-52H no longer carries a defensive aerial gunner, or the tail-mounted defensive armament that he controlled, the role of the only enlisted aircrew member on the B-52 Stratofortress must be recognised. Here, Master Sergeant (retired) Jim Sellars explains what was involved in defending the bomber against enemy fighter attack:

OPPOSITE Jim Sellars sitting at his gunner's station in the forward compartment of a B-52G, during Operation Desert Storm in 1991. (*Jim Sellars*)







ABOVE The B-52G was armed with four M3 .50 calibre machine guns mounted in the remotely operated rear turret. *(Jim Sellars)*

'Gunnery had been used in military aircraft as early as World War One, when they flew as observers manning a single machine gun mounted on the outside of the cockpit. During World War Two heavy bombers such as the B-17 and B-29 were manned with several gunners to defend the aircraft from all directions. In 1945 initial design requirements called for the B-52 to have five or more gunners, but as the design evolved into a high-altitude, long-range, subsonic jet bomber the Air Force decided on a single gunner positioned in the tail.

'I enlisted in the US Air Force in 1985 and during Basic Military Training I volunteered to train as a B-52 gunner. My first training requirement was to complete physiological training at Beale AFB, California. Here I received classroom instruction on the principles of physics governing altitude, which was followed by a hypobaric altitude chamber flight where I experienced first hand the effects of altitude.

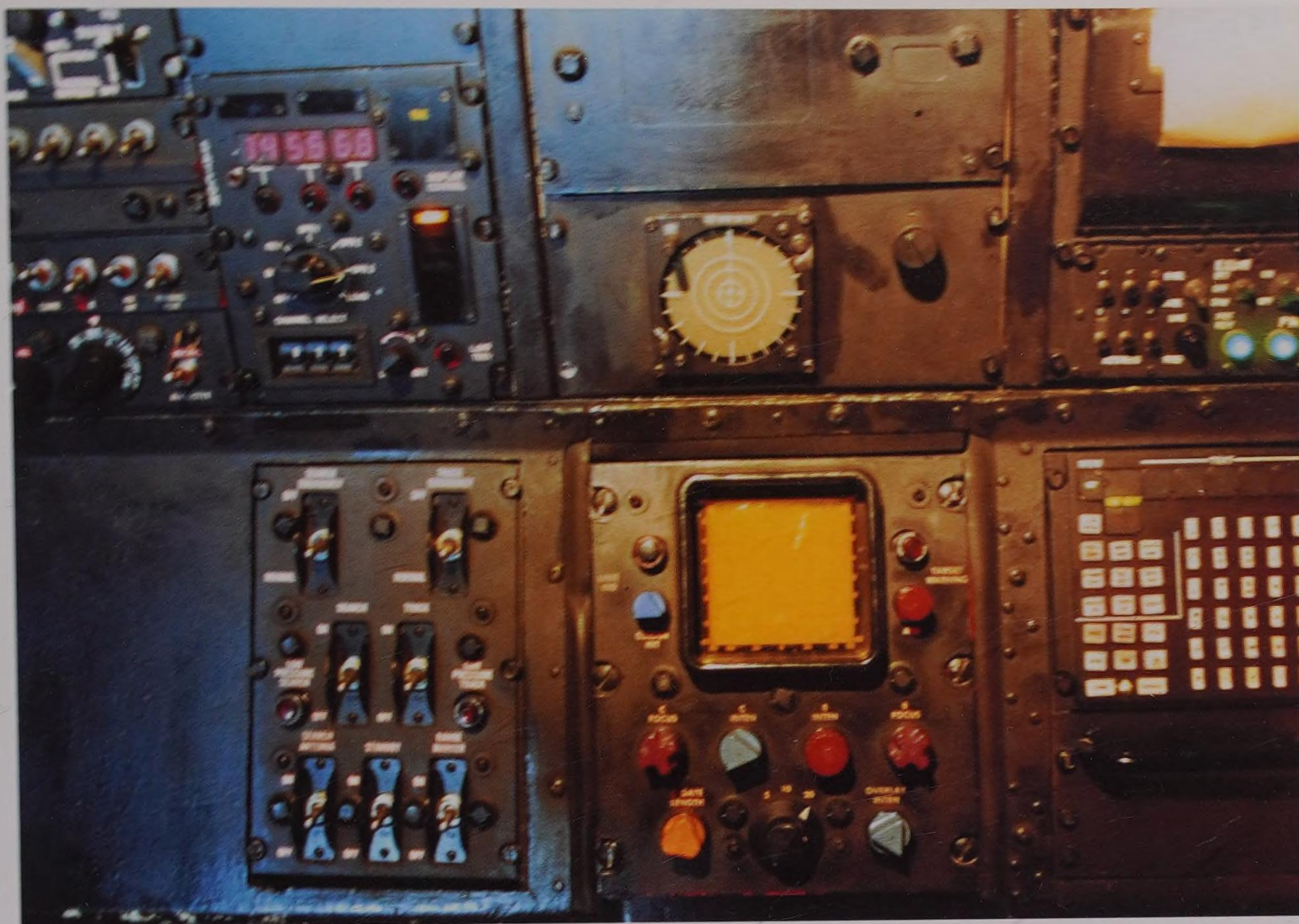
'For many students the next phase of training was at Homestead AFB, Florida, for basic water survival training, and then to Fairchild AFB, Washington, for basic land survival, escape and evasion, and resistance training. This training

prepared aircrew in the event they had to bail out over land or water during peacetime or in combat.

'I was assigned to the 4017th Combat Crew Training Squadron at Castle AFB, California, and completed Enlisted Aviation Undergraduate School. This was an introductory course to the responsibilities of being an enlisted aircrew member. Upon completion of this course I began gunner training.

'The first phase of gunner training included classroom instruction on basic radar theory, description and operation of equipment, fire control system (FCS), normal/emergency procedures, crew duties and bomber defence procedures. The training was fast-paced and challenging, especially for most of us who were just a year or two out of high school.

'The aircraft we trained on was the B-52G, which was an improved variant of the B-52 that started with the A model back in 1952. The aircraft continued to use the same turret-mounted quad .50 calibre machine guns, but now had an improved FCS that was remotely operated by the gunner, who was relocated to the forward compartment. While the new system was a welcome improvement, many believed the relocation of the gunner from the tail to the forward compartment was a



LEFT A view of the gunner's station showing the radar screen and various controls for the Avco-Crosley AN/ASG-15 fire control system.
(Jim Sellars)

drawback: pilots had enjoyed the benefit of having a set of eyes scanning the bomber's vulnerable six o'clock.

'The B-52G was equipped with the Avco-Crosley AN/ASG-15 FCS, which was capable of searching the defence zone, detecting and tracking targets, and providing gunfire coverage against those targets. The system allowed the gunner to acquire a target quickly and easily, accurately position the guns, and effectively commence firing. Upon conclusion of an attack the gunner could then quickly acquire a new target.

'Some of the characteristics of the FCS were separate search and track radars, which allowed continuous searching even while locked on to a target; and a monopulse track radar, so that tracking errors could be obtained quickly and allow for accurate tracking information. The turret used a hydraulic drive system, which gave it rapid response for tracking fast-moving targets. The dual carriage turret rotated within the limits of $\pm 60^\circ$ in azimuth and $+40^\circ/-50^\circ$

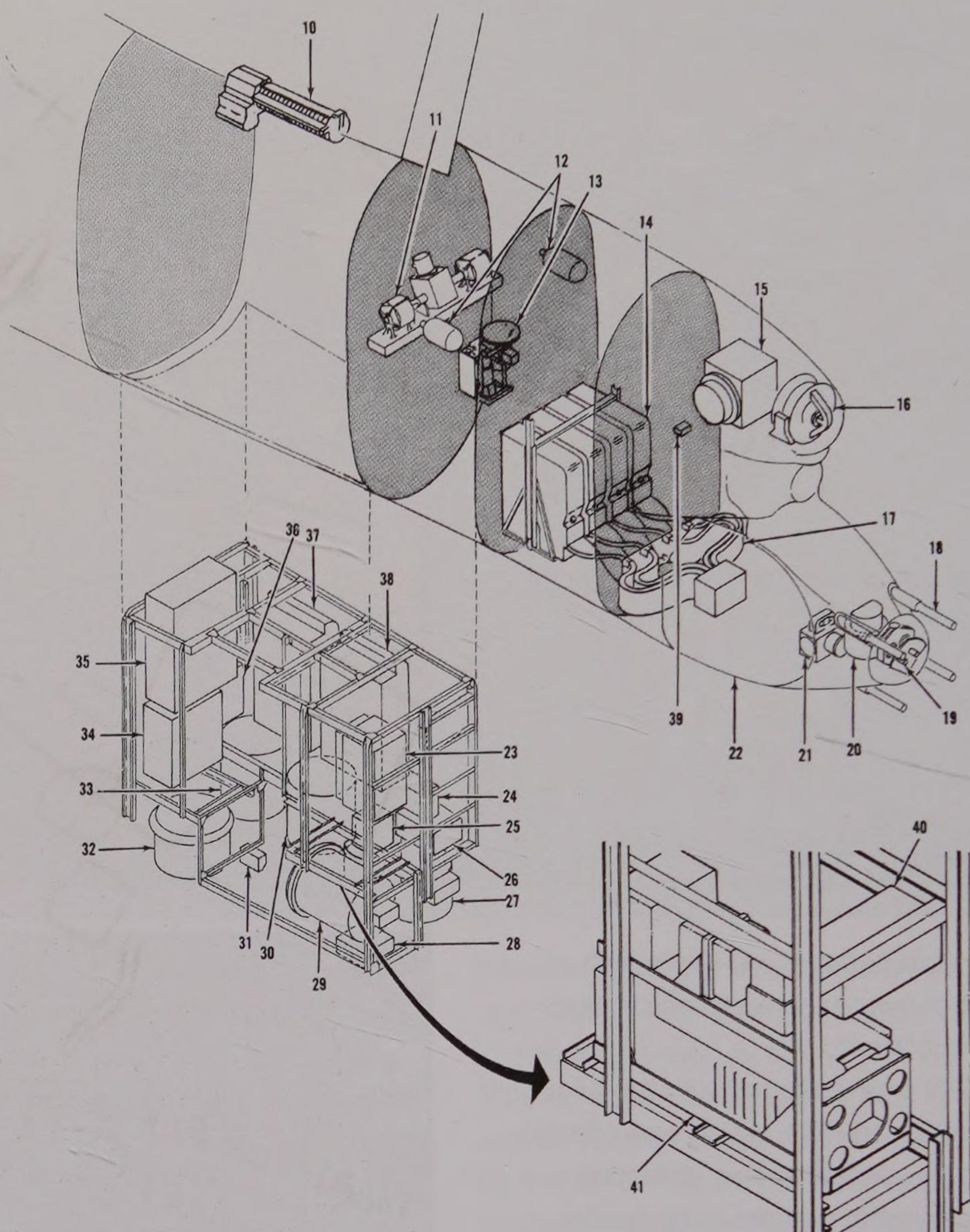


RIGHT Another view of the gunner's station, with seat and harness just visible to the right.

(Jim Sellars)

The tail-mounted components of the gun's fire control system (FCS). (USAF)

- 10 Electronic rack hoist
- 11 Ammunition platform hoist
- 12 Pneumatic storage bottles
- 13 Air compressor
- 14 Ammunition boxes
- 15 Search frequency converter transmitter
- 16 Search antenna
- 17 Ammunition chuting
- 18 M3 .50 calibre machine gun
- 19 Track antenna
- 20 Track frequency converter transmitter
- 21 Transmitter sub-assembly
- 22 Turret assembly
- 23 Control central
- 24 Voltage regulator
- 25 Track modulator
- 26 Auxiliary power supply
- 27 Search modulator
- 28 Track junction box
- 29 Target position computer
- 30 Search power supply
- 31 Radar set adapter
- 32 Pulse sweep generator
- 33 Track power supply
- 34 Auxiliary central
- 35 Power central
- 36 Search junction box
- 37 Servo central
- 38 Computer central
- 39 RF filter
- 40 FCS elevator stow box
- 41 FCS evaluator



RIGHT A B-52G with the FCS equipment rack lowered for maintenance.
(Jim Sellars)



in elevation. The entire system was stabilised against pitch and roll of the aircraft and turret by the use of a gyro system, and an accurate and automatic computer was used to solve the fire control problem.

'Armament on the B-52G consisted of four M3 .50 calibre machine guns mounted on the turret's elevation carriage. Each gun was supplied with a capacity of more than 600 rounds of ammunition. Each gun was capable of a fire rate of approximately 1,200 rounds per minute, with maximum firing range of about 1,500 yards. The guns also included pneumatic gun chargers and heaters.

'The electronic rack located in the tail of the aircraft contained the equipment of the FCS. These units resolve and relay the information from the search and tracking systems to the forward compartment, where

it may be observed on the gunner's indicator scope. Located on the electronic rack is the computer central, which solves the fire control problem created by windage, gravity, bullet jump, time of flight, and azimuth and angular displacement of the guns.

'The FCS radar is composed of two parts: a search radar set and a track radar set. Though these radars operate independently they are synchronised and use a common radar indicator scope and presentation. The radar automatically warns of approaching aircraft and enables the gunner to select and acquire a specific target. Then the FCS automatically tracks the selected target and supplies target position data to the appropriate components of the system.

'The I-band search radar was designed to detect targets aft of the bomber, scanning a sector 166° in azimuth and 120° in elevation to a range of approximately ten miles. The monopulse I-band track radar automatically tracks preselected targets furnishing range, azimuth, and elevation error data to the computer and servo central. In the event of search radar failure, the track radar may be used to perform the search functions but with reduced performance characteristics. The system had the capability to track targets up to 7,000 yards away.

'The gunner's station on the G model was located in the forward compartment facing backward alongside the electronic warfare officer. The gunner's equipment consisted of the FCS controls, which included the radar control panel, FCS control panel, ammo counters and stowable gun control handles/indicator scope. The gunner also had controls to operate the Air Force satellite communications (AFSATCOM) equipment.

'Gunner students learned the nuts and bolts of the FCS, procedures on how to operate the system, and procedures and tactics on how to employ the system against enemy fighters in combat. The knowledge learned in the classroom is reinforced with instruction in the flight simulator prior to flight training. Upon completion of classroom and simulator training gunners are awarded their enlisted aircrew wings and proceed to the flight line for their first flight.

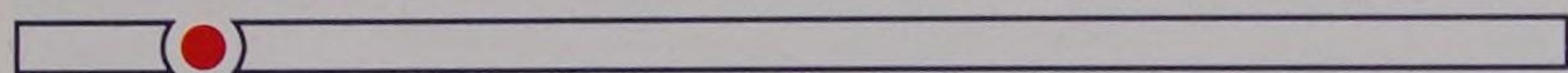


'Gunner students performed their flying training with the 328th Bombardment Squadron at Castle AFB, completing about ten training flights. On the final flight they are administered a flight evaluation or check ride before being deemed a qualified mission-ready gunner. Upon satisfactory completion of their training requirements they receive their coveted gunner's coin welcoming them into the fraternity of B-52 Defensive Aerial Gunners.

'My first assignment was at Barksdale AFB, Louisiana, with the 62d Bombardment Squadron, which was a part of the 2d Bombardment Wing. I completed my time as an instructor defensive aerial gunner with a total of 1,930 flight hours (175 hours' combat time) in the B-52G. I went on to fly as a flight engineer in other aircraft and retired as a master sergeant in 2006.'

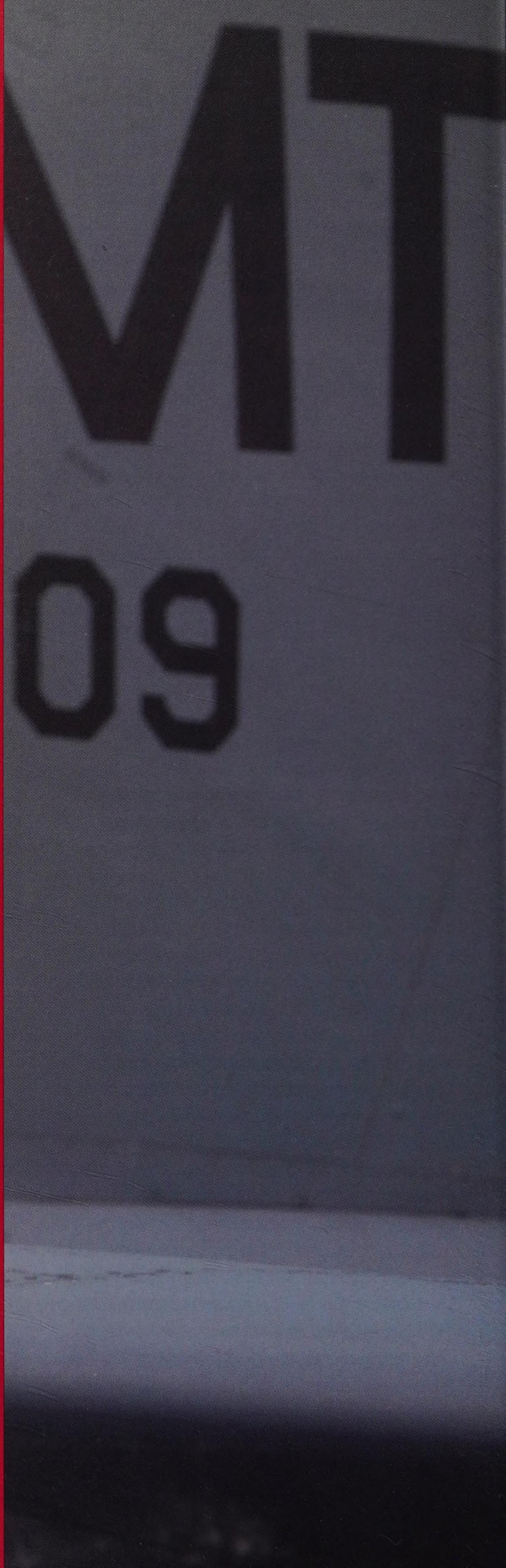
ABOVE Jim Sellars sitting in his gunner's station in a B-52G in 1988. (Jim Sellars)

Maintaining the Stratofortress: the maintenance crew's view

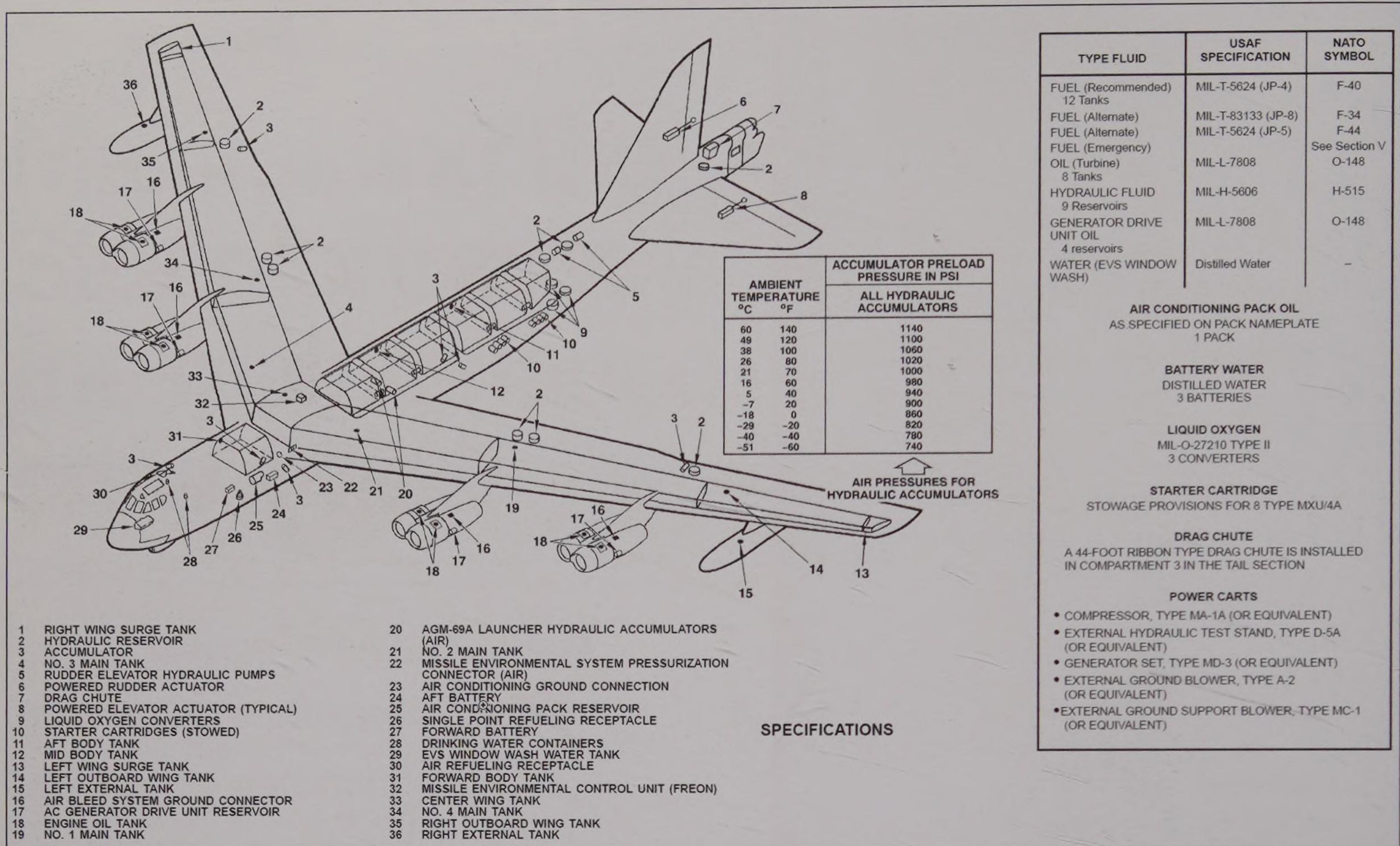


It goes without saying, but can never be overstressed, that without the commitment and expertise of aircraft maintainers there would be very few B-52 sorties flown. In this chapter, Ken Kimmons, a B-52 maintainer for many years, provides a brief precis of what it took to keep the Stratofortress in operational condition.

OPPOSITE The B-52's brake chute is housed behind the vertical tail and is a 44ft ribbon type. Housed in 'compartment 3', it is repacked after each sortie and then installed in a canister prior to the next. The braking chute significantly reduces brake pad wear and tear in addition to improving landing performance and safety. (USAF)

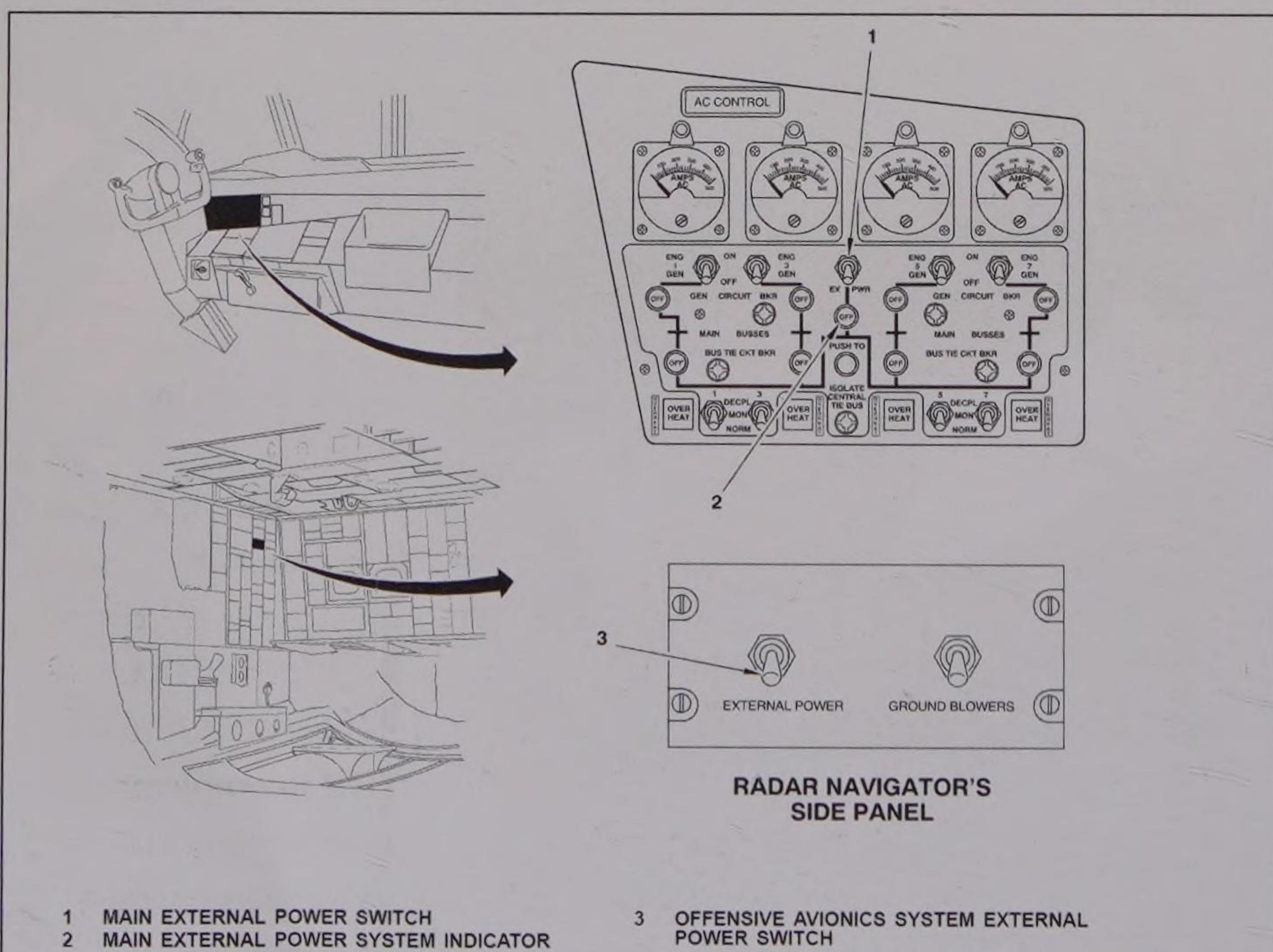






ABOVE The B-52H servicing diagram lists 36 main servicing points and outlines a range of hydraulic accumulator pressures. Despite its age the B-52 is serviced to such a high standard that it boasts a mission-capable rate worthy of a much more modern design. (USAF)

BELOW The main external power switch – flipped to bring the aircraft to life once power has been supplied – is located on the co-pilot's right side console. The crew chief will need to use this switch in order to conduct a number of his pre- and post-flight checks. (USAF)



Preflight

The preflight involved inspecting, servicing, maintaining and repairing the aircraft as required. The preflight crew usually had three ground crew members. You had to check out your toolbox, launch kit (interphone ground cord, head sets, safety vest and wands), fuel dip sticks, and tyre pressure gauge from the tool room. After arriving at the aircraft, you checked the aircraft forms to make sure that it was safe to apply power and work on the aircraft.

The crew chief would usually apply power to the aircraft and check the fuel load and LOX (liquid oxygen) quantity. While he or she was doing that, the other members of the crew were removing and stowing engine and duct plugs along with the pitot tube covers.

After the fuel and LOX quantities were checked, we would shut off all power and do the maintenance checks that required the power to be off. These included draining wing fuel surge tanks and fuel tank sumps. We then serviced the LOX, and dipped the fuel tanks to ensure that the proper amount of fuel was in each one. This was also a way to verify that the fuel quantity gauges were correct.

‘After these items were done we checked tyre pressure, landing gear strut extension and accumulator pressure. We also checked the tip protection gear shimmy damper for proper servicing and hydraulic system reservoirs for proper fluid level. Then we checked the EVS, FLIR and STV window wash tank to ensure that it had a proper water level. We would then service any of these items, as required.

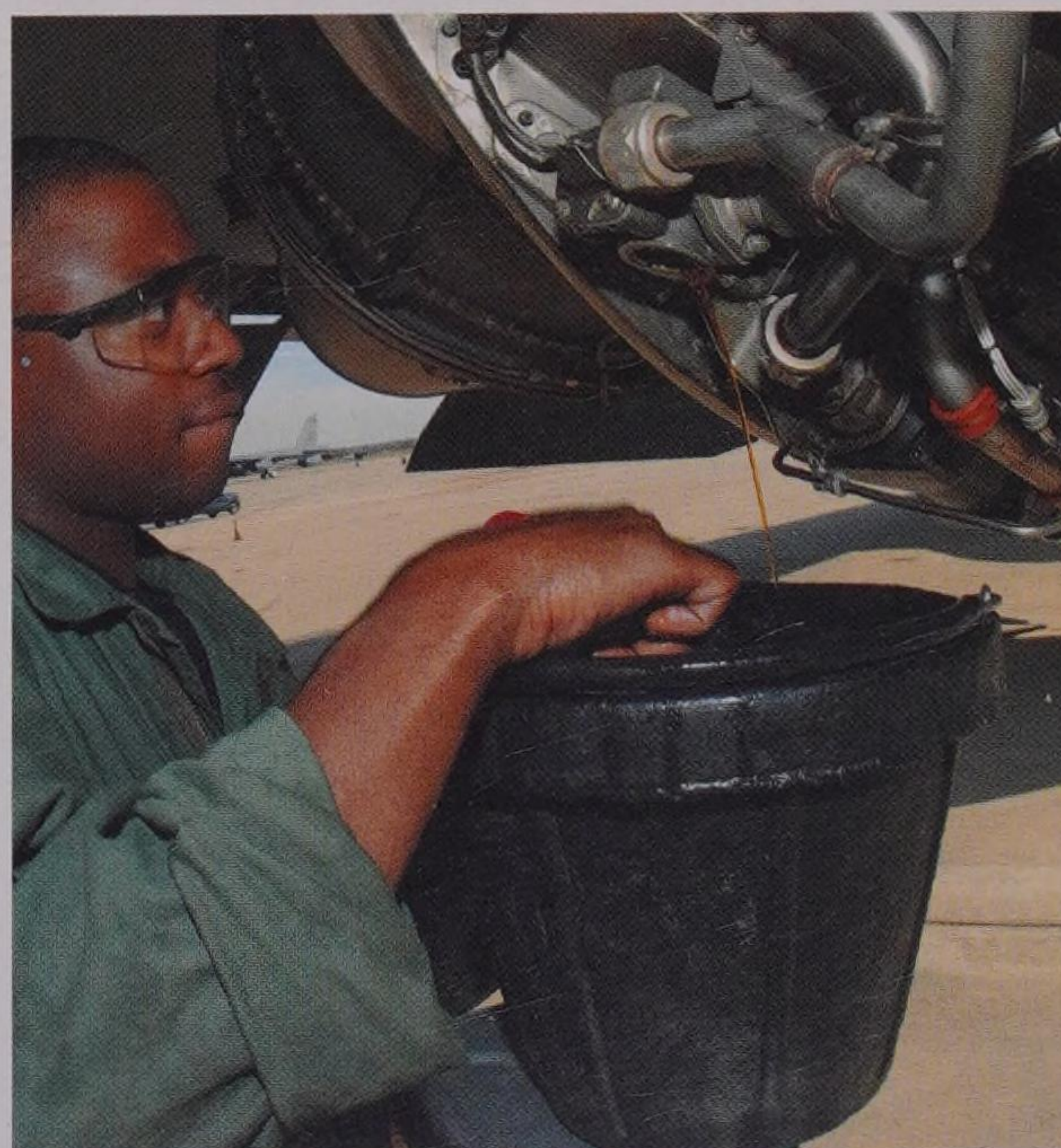
‘After servicing we wiped down the exposed portion of the inner landing gear struts with hydraulic fluid and wiped off the bottom of the engine cowling to remove any oil and hydraulic fluid that may have come out of the drains. And, with all this done, we could then begin our actual inspection.

‘The aircraft was broken down into five “work areas” for inspection purposes. Areas 1, 2 and 3 were the fuselage, area 4 was the left wing, and area 5 the right wing. The crew compartment inspection involved checking the aircraft lights (interior and exterior) and a number of switches, handles and indicators. These included the ejection seat checks, as well as fire-fighting, first

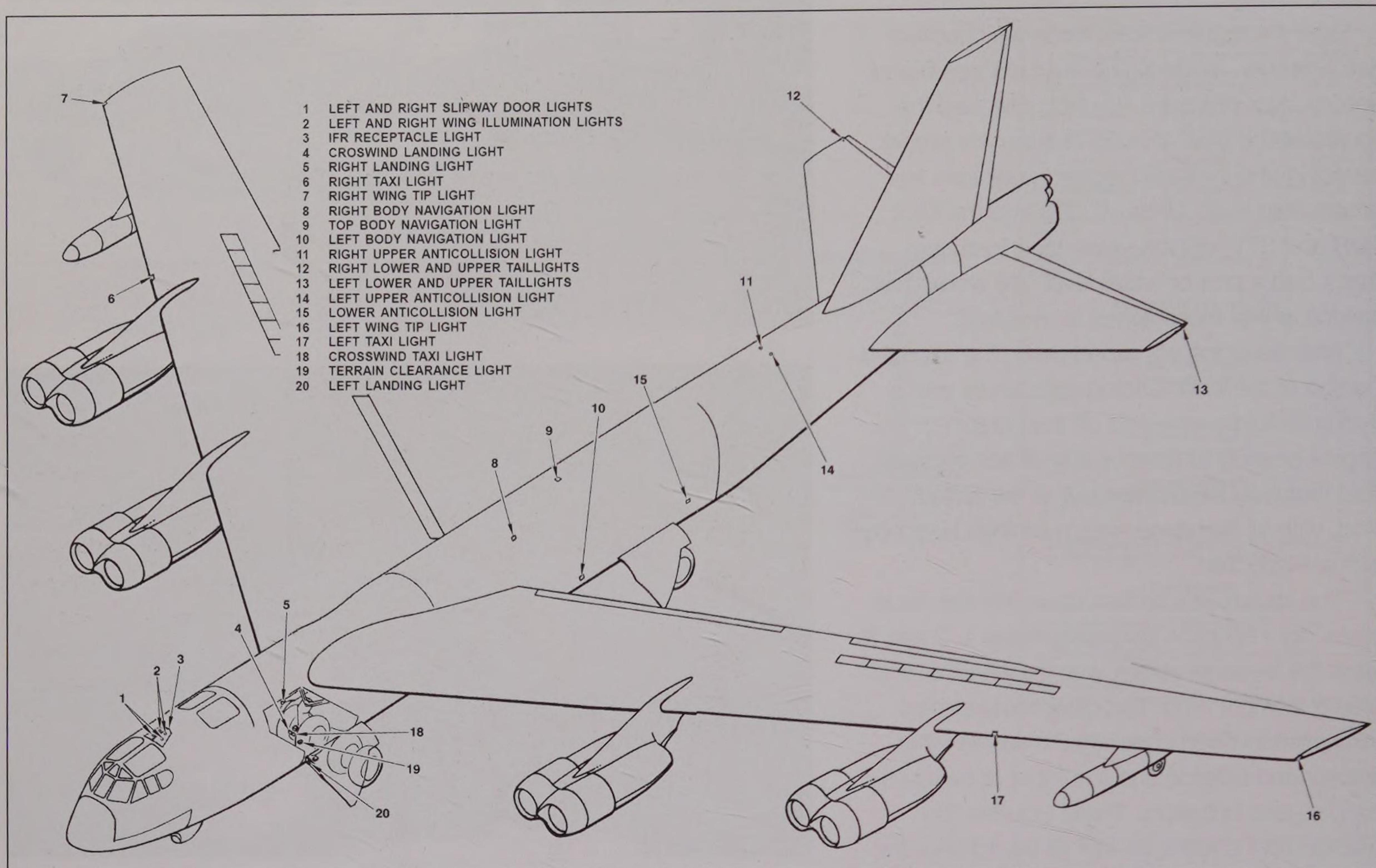


ABOVE Liquid oxygen – vital for the crew’s survival in the rarefied atmosphere above 18,000ft – is exceptionally volatile and requires suitably careful handling. Here, a B-52H has its LOX serviced via one of three liquid oxygen convertors located behind the aft wheel well. (USAF)

LEFT The aircrew will report a list of faults following each sortie, and in some cases this may necessitate that a specialist removes a component or sub-component in order to troubleshoot the problem. Here, an avionics specialist unscrews the G/H-Band ‘conical horn/slot’ of the ALQ-155. (USAF)

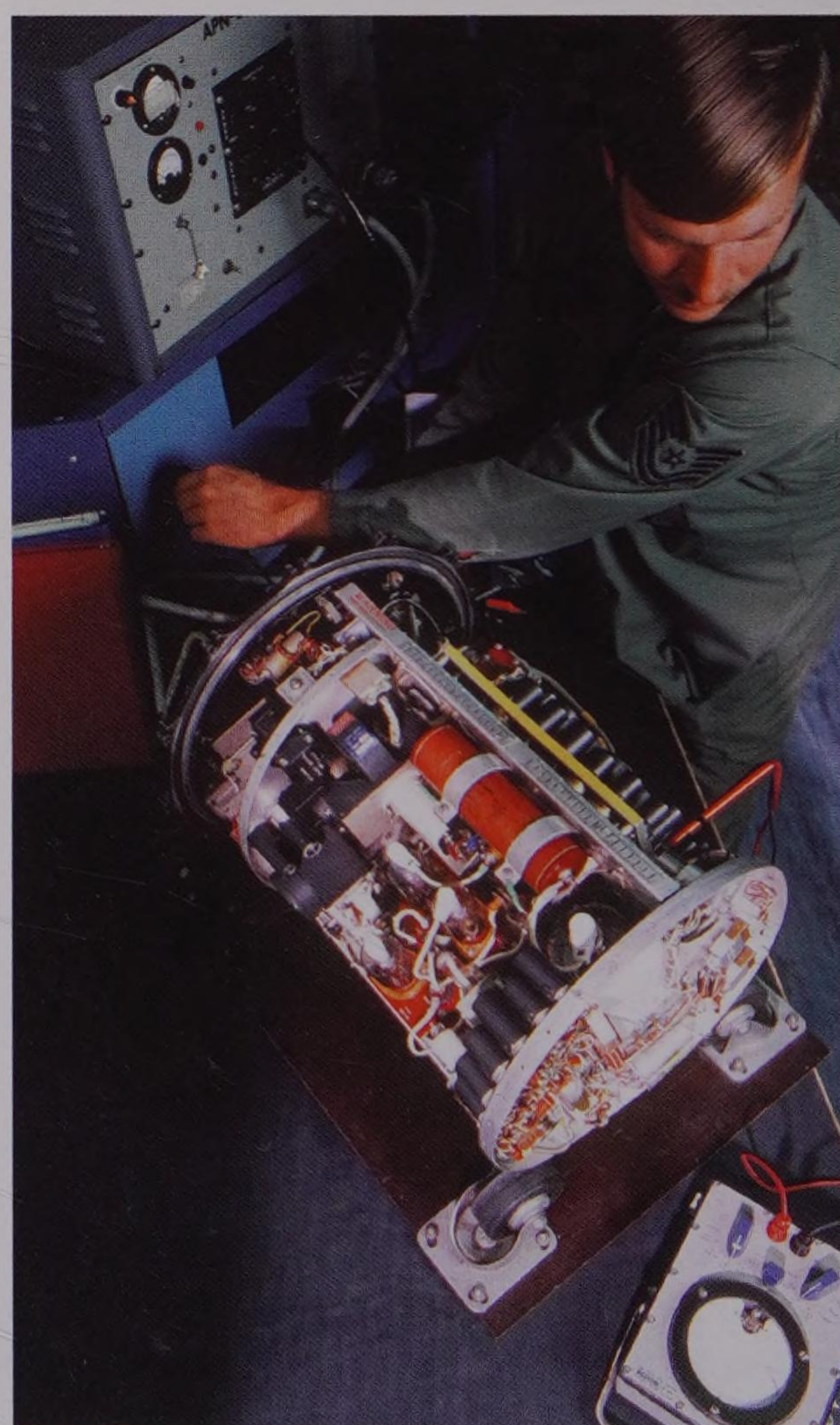


LEFT Checking fluids, as is being done here by a B-52H maintainer, provides the opportunity to check for contaminants that could either directly lead to problems later, or may indirectly indicate impending problems. (USAF)



ABOVE AND BELOW There are 20 external lights that need to be checked before the crew arrive to sign for the aircraft. The size and shape of the aircraft mean that some lights – such as this port wingtip light – are easier to service than others. (USAF)

RIGHT This rather large cylinder is actually a B-52's tube-run rendezvous beacon light. Whilst the light may no longer be manufactured, scavenging spares from decommissioned B-52s sitting in the boneyard allows maintenance specialists to keep the ageing aircraft on their flight schedules and increase the mean time between failures. (USAF)





aid equipment and escape equipment checks. The bulb racks had to be inspected and filled as needed too. With all inspections and maintenance in the crew compartment completed, we pulled and stowed the ejection seat safety pins.

‘The exterior of the front fuselage involved opening drains to remove moisture from both the fuselage and the airspeed instrument systems. We had to check pitot tubes for pitting and corrosion, and make sure that both the pitot and static ports were clear. In the forward wheel wells we checked panels for security, then inspected all of the tyres for damage and correct inflation pressures. Similarly, the hydraulic accumulators were checked for proper pressure, and the landing gear struts were inspected for proper extension and cleanliness if we had not done these items previously.

‘Next we had to reset the trip signal indicators for the electrical generators. The bomb bay area was checked for loose equipment, fuel and hydraulic leaks, and we ensured that the forward body hydraulic system shuttle valve handle was in the proper position and safety wired.

‘In the aft wheel wells we inspected the same items as the front wheels, but with the



addition of the bomb bay door supports for proper storage, and aft body hydraulic shuttle valve for proper position and safety wiring. We also had to ensure that the “crawlway” door was closed. All panels and doors were also checked to be sure that they were secure.

‘Moving to the wings, we inspected the engine intakes for foreign objects and the pod nose domes for security. We looked at the wing surfaces for signs of any fuel leaks, inspected engines for leaks, then checked hydraulic fluid levels in the reservoirs, ensured that accumulator pressures were acceptable, and finished by servicing the shimmy damper if we had not done them previously. All panels also had to be checked to be sure that they were secure.

‘The aft section check of the aircraft ensured that the equipment inside was properly secured. The transformer rectifiers were checked for proper airflow and operation. The stability augmentation system filter buttons were checked to ensure that they were not popped and, as you might guess, all panels and doors were checked to ensure that they were closed and secure.

‘With the inspections complete – and any issues rectified – we installed the pitot tube

FAR LEFT AND LEFT
With the aircraft serviced and armed, the crew bus will deliver the aircrew. Once the forms are checked and signed the walk-around will begin. During this time the crew chief will be close at hand to answer any questions relating to the serviceability of ‘his’ BUFF. Ladders are required to allow access to the taller areas of the airframe and weapons pylons. (USAF)

RIGHT Two crew chiefs from the 5th Bomb Wing, Minot AFB, prepare to launch their B-52H on a night sortie from Guam. The 5th BW took the first deployment rotation to Guam following US Pacific Command's decision to station a bomber force there. (USAF)



BELOW A crew chief marshalls a 62d Bombardment Squadron B-52H during the Strategic Air Command competition Proud Shield '88. Whilst avoiding obstacles and taxiing safely is ultimately the responsibility of the aircraft commander, the crew chief's unique viewpoint puts him in an excellent position to check wingtip clearances and braking points. (USAF)

covers, engine intake plugs and duct plugs and gave the flap screws a light coat of oil to keep away corrosion. The aircraft forms were then transcribed, after which the panel inspection and exceptional release were signed off. And then we waited for the flight crew to show.'

Recovery and post-flight

The aircraft was marshalled up to the desired spot on the parking ramp and wheel chocks were installed and the interphone connected. The pilot would ask if engines were clear for shutdown. While engines were being shut down the navigator would open the hatch and drop out the landing gear safety pins and bypass keys along with the aircraft ground wires.

'With the engines shut down and the landing gear pinned, the crew got out of the aircraft and

on to the crew bus. Someone would go into the cockpit and put the safety pins into the ejection seats while the other ground crew members were checking engine oil, taking "soap" (spectrographic oil analysis programme) samples, if required, and disconnecting the bomb doors.

'The flare ejection door on the bottom of the tail of the aircraft also had to be opened and the aircraft ground wires installed. The person in the cockpit pinning the ejection seats would bring the urinal out of the aircraft and dump it. The "honey bucket", which was used for solid human waste, would have its bag removed by whichever crew member had used it in flight. The tyres were inspected for damage and brakes for overheating prior to towing the aircraft into the parking stub.

'After the aircraft was properly parked in the parking stub and grounded, fire extinguishers were placed in front of each wing. Preparations were then begun for refuelling the aircraft. The exposed inner portion of the landing gear struts had to be cleaned and wiped down with hydraulic fluid. All unneeded lights and equipment had to be turned off and certain circuit breakers were pulled. The fuel sheet was filled out for the required fuel load while we waited for the fuel folks to arrive at the parking stub with their equipment.

'After refuelling was completed we loaded a new drag chute into the aircraft and started our inspections. Just as with the preflight inspection, the aircraft was divided into work areas for the post-flight inspection. Area 1 was the front fuselage, cockpit, front wheel wells,



bomb bay and aft wheel wells, areas 2 and 3 were the left and right wings, and area 4 was the aft fuselage.

'Area 1 in the cockpit involved checking that the ejection seats were pinned, arm rests were down and ejection hatch safety stripes were visible, engine firewall shut-off valve T-handles were pulled, and circuit breakers were pulled as required. Outside on the fuselage the IFR (in-flight refuelling) receptacle contacts had to be cleaned and sprayed with a clear lacquer, but this was only done with the IFR doors open and a safety strut installed.

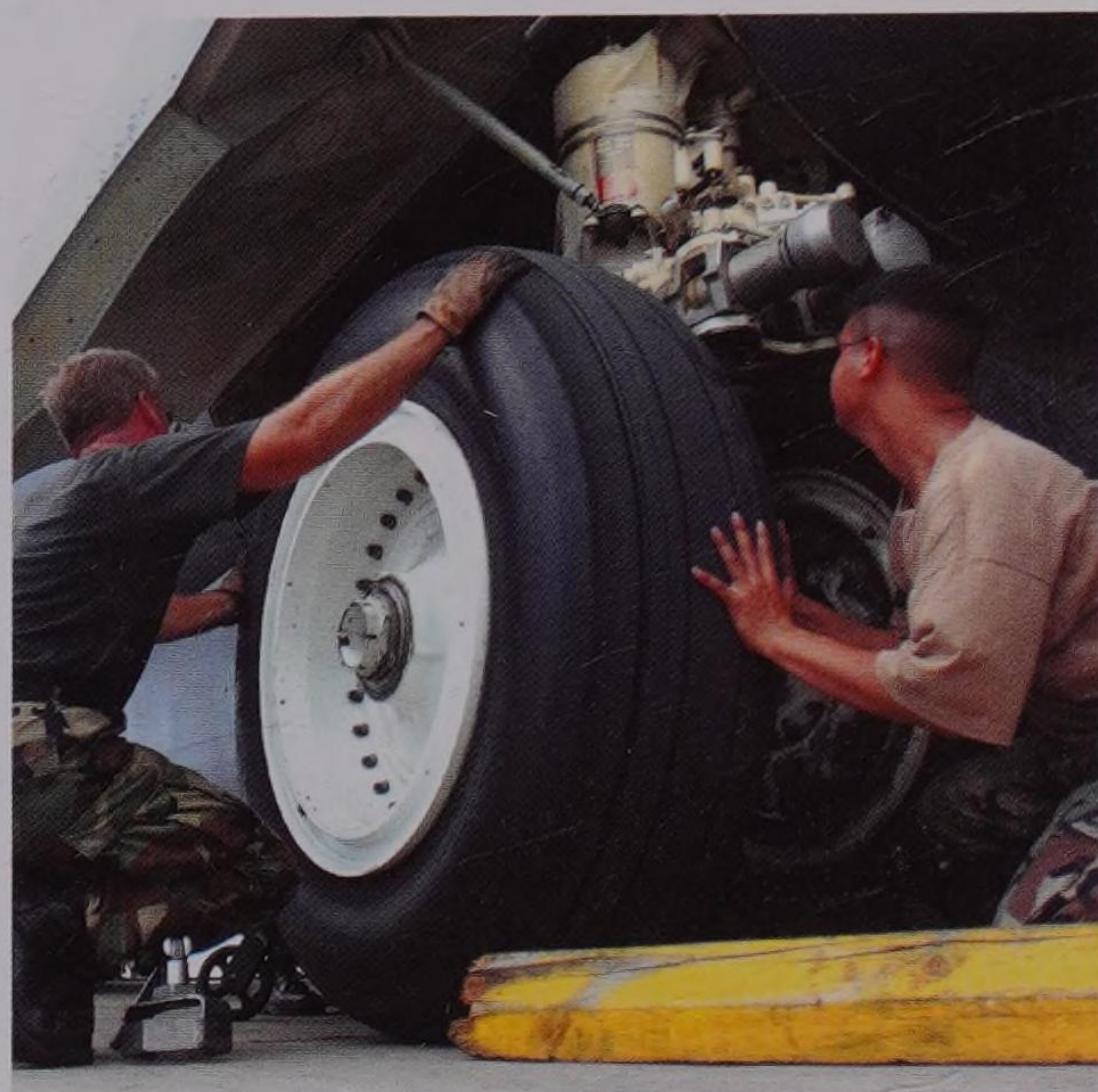
'Landing-gear struts and brakes had to be checked for leaking, damage and overheating, although the struts were also checked to ensure proper cleaning of any exposed inner strut. Once again the tyres had to be checked for damage, cuts and excessive wear. The aircraft batteries were checked for security and signs



ABOVE Not every task falls to the crew chief. Here, a crewman installs protective covers to the front windows of a B-52H. The covers protect against the elements, prolonging the life and optical quality of the toughened Perspex. (USAF)



LEFT A series of views showing the arrangement of the B-52's main landing gear and the process for changing a tyre – note the use of an hydraulic jack mounted directly beneath the main strut. (USAF)



RIGHT Connecting the support rods to the Stratofortress' bomb bay doors locks them in place and is a task that is completed prior to any maintainer or weapons troop working in that area.
(USAF)



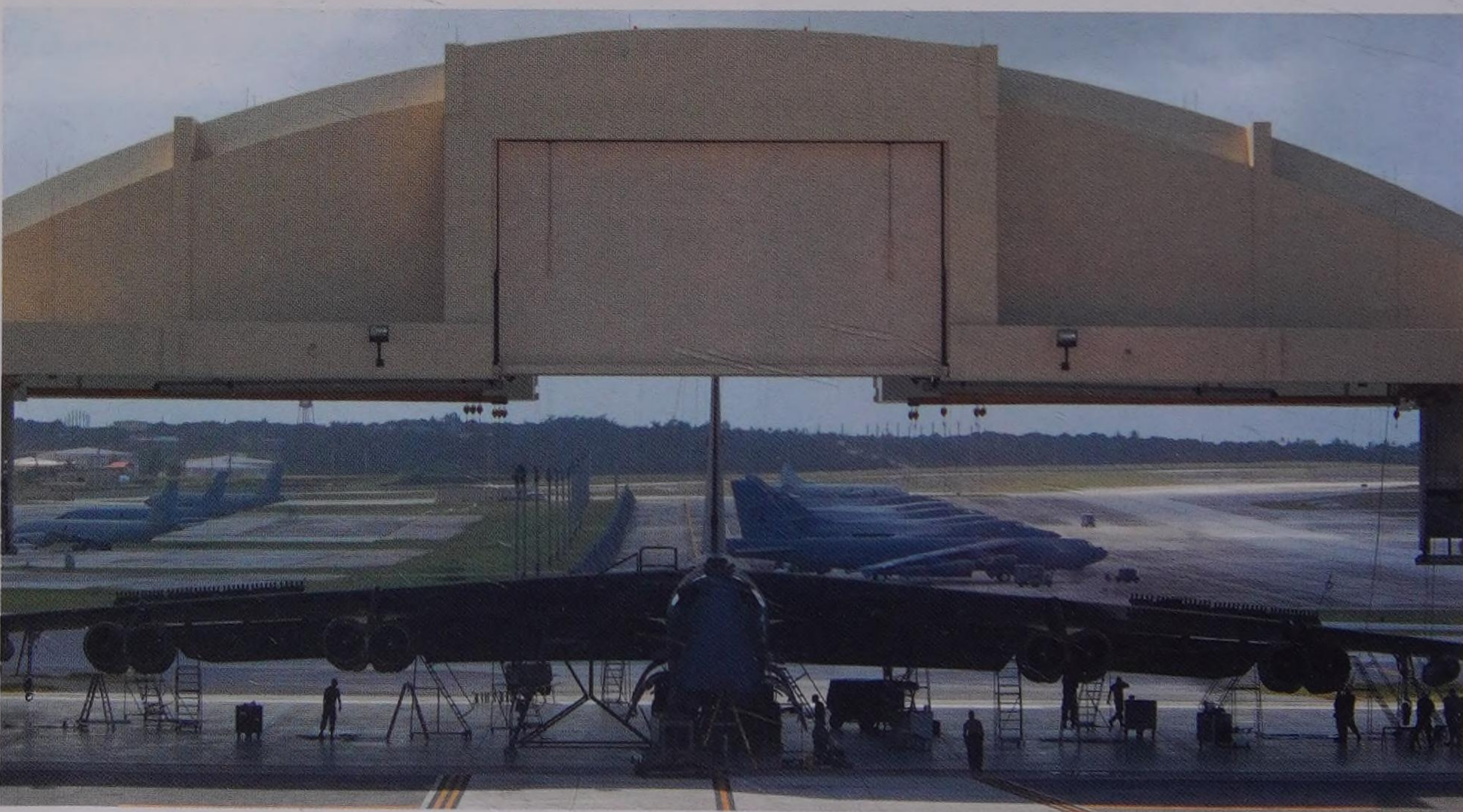
of overheating. Doors, panels and aircraft skin were checked for damage.

'We next checked that the safety struts were installed in the bomb bay, and, assuming

that they were, we inspected the doors and interior for any leaks or damage. The aft wheel wells were checked for the same items as the front wheel wells. The aft section of the aircraft had to be checked to see if the SAS control units had failure flags showing, or the hydraulic system filters had buttons popped which would indicate that the filters were clogged.

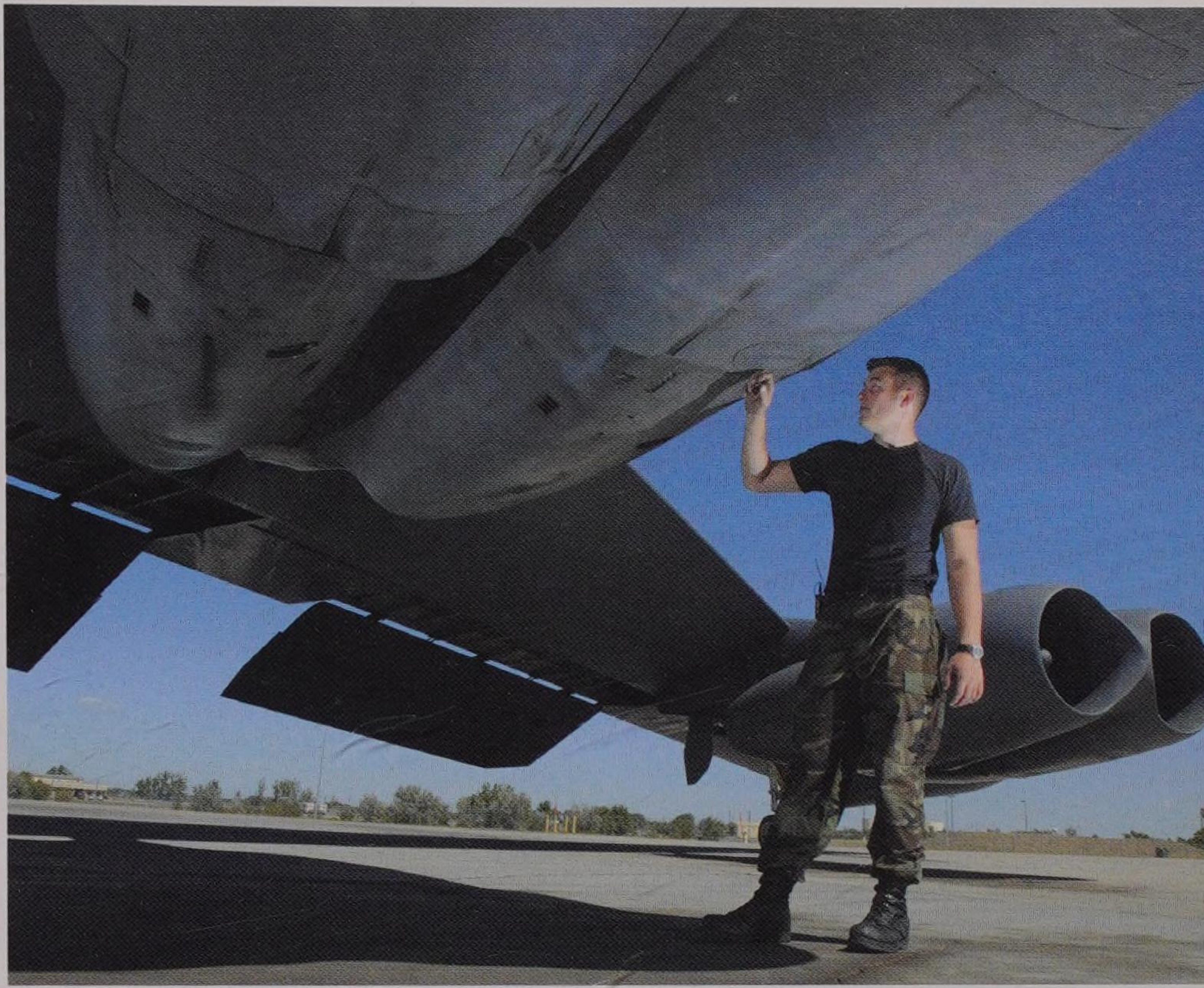
'The wings were checked for fuel leaks and damage. The tip protection gear were checked for tyre damage and proper cleaning of exposed inner struts. The engine intakes and exhausts were checked for damage to engine blades and vanes. Again, the nose domes were checked for security and the engines for leaking. In particular we checked whether any seals were showing signs of wear and damage. After the inspections were complete, all discrepancies were called in to maintenance control and the aircraft forms were properly documented.'

RIGHT Whilst servicing between sorties can be accomplished in the open, Phase inspections expose the aircraft to the elements for days on end and must therefore be conducted under cover. The big BUFF requires a similarly big Phase inspection hangar, as seen here – Hangar 1 at Andersen AFB, Guam. The hangar's price might surprise the casual observer: \$34 million in FY96 dollars. (USAF)





ABOVE AND RIGHT A crew chief of the 43d Field Maintenance Squadron AGE (aerospace ground equipment) branch wheels an external power generator in front of a B-52 of the 43d Bombardment Group. With the Phase inspections complete, the aircraft will undergo ground checks to ensure that all systems operate properly. With everything in order, the crew chief conducts his final walk-around before handing the aircraft over to the flight crew. (USAF)



Before the B-52 can be returned to normal scheduling following a Phase inspection (or the more thorough planned depot maintenance, PDM), it must first undergo a functional check flight (FCF) in the hands of an experienced crew of instructors. The FCF will explore the full envelope of the aircraft, ensuring that all systems work correctly. (USAF)



Appendix A

Production table: production standard aircraft

	B-52A	B-52B	B-52C	B-52D	B-52E	B-52F	B-52G	B-52H
FY								
FY 54	3							
FY 55		13						
FY 56		35	5	1				
FY 57		2	30	92				
FY 58				77	100	10		
FY 59						79	50	
FY 60							106	
FY 61							37	20
FY 62								68
FY 63								14

BELOW LA tail codes signal that this B-52H belongs to the 2d Bomb Wing, stationed at Barksdale AFB, Louisiana. The blue tail stripe further narrows ownership down to the 20th Bomb Squadron. (USAF)

The US Air Force ordered 13 B-52As, of which ten would actually be built to B-52B standard. The ten A models were used by Boeing for test and development, while the B models entered USAF service from 29 June 1955 onwards. Later, one B-52A and one B-52B were converted to NB-52A and NB-52B respectively for NASA's X-15 programme, while 27 B-52Bs would be converted to RB-52B standard for the Air Force.

All A, B and C model Stratofortresses were built by Boeing's Seattle plant, but with the wind-down of B-47 production and the larger volume of orders for the 'new' B-52D, Boeing's Wichita plant was also tasked to build the big

bomber. Of the 163 D models ordered, Wichita was responsible for the manufacture and handover of 62 airframes.

Production of the less numerous B-52E and B-52F was more evenly split, with Seattle producing 42 of the 100-strong order of E models and 44 of a total of 89 F models. However, by the time the B-52G was ready for manufacture Boeing had already taken the decision to move production exclusively to Wichita, from whence all G and H models would subsequently come. In 1962 Boeing manufactured the last ever B-52 – it was the 744th Stratofortress the company had built.



Appendix B

B-52H US Air Force Units, 2012

As of February 2012, the US Air Force had three Wings, stationed at two Air Force Bases, assigned to fly the B-52H.

Barksdale AFB, Louisiana, today remains the home of the Stratofortress. It has been associated with the aircraft since the arrival of the B-52F in April 1963. Barksdale's host operator, the 2d Bomb Wing (BW), is also the oldest Bomb Wing in the Air Force.

2d BW consists of three squadrons of B-52Hs – a training squadron, the 11th Bomb Squadron (BS); and two operational squadrons, the 20th BS and the 96th BS. Once part of Strategic Air Command's nuclear deterrent force, the Wing was transferred to the ownership of Air Combat Command (ACC) in 1992. More recently (since February 2010), it has operated its 44 B-52Hs under the ownership of the newly-created Global Strike Command.

All 2d BW B-52s carry 'LA' tail codes, but the colour of the tail stripe helps identify the specific BS.

Yellow stripes are applied to the 11th BS' aircraft, this unit being sometimes referred to by its mascot name 'Mr Jiggs'. The 11th BS is a comparative newcomer to B-52 operations, having transferred from being a ground-launched cruise missile operator to a Stratofortress training squadron in 1994.

The 'Buccaneers' of the 20th BS carry a blue tail stripe, and have flown the B-52 since converting from the B-47 bomber in 1963.

Finally, the 96th BS 'Red Devils' have a black tail stripe. The squadron was reactivated to



RIGHT Barksdale is the spiritual and physical home of the B-52, and is home to the 2d Bomb Wing and Air Force Reserve Command's 307th Bomb Wing. Here, a B-52H of the 340th Weapons School – also based at Barksdale – drops live GBU-31 JDAMs during a training exercise over the Nevada Test and Training Range. (USAF)



ABOVE AND BELOW

Enduring sub-zero conditions for some of the year, Minot AFB lacks the sunny charm of Barksdale. Even so, its role as one of only two B-52H bases ensures that it retains a special status in the eyes of the BUFF aficionado. (USAF)

operate the B-52H in 1993 following more than two decades of inactivation.

In addition to Barksdale's host Wing, the US Air Force Reserve Command's 307th Bomb Wing is also resident on the base. Known as the 307th Bombardment Wing during SAC days, the unit was inactivated in 1975. It only reactivated in January 2011. The 307th BW's aircraft are easily distinguishable from 2d BW aircraft through their use of 'BD' tail codes and a blue/yellow chequered tail stripe. There are two AFRES squadrons, the 93d BS and the 343d BS. Finally, the 49th Test and Evaluation Squadron (TES) is also based at Barksdale. Part of the 53d Wing, the squadron is responsible for testing, evaluating and developing nuclear and conventional weapons systems and tactics for the B-52 force.

The second base that operates the B-52H is Minot AFB, located in North Dakota. Here, the 5th Bomb Wing forms part of Global Strike Command's Eighth Air Force, but was also once part of SAC and then ACC. The Wing's aircraft feature 'MT' tail codes, while two different tail stripe designs represent the two different squadrons that comprise it, 23d BS and 69th BS.

The 23d BS 'Bomber Barons' have red-striped tails. The squadron has a long-standing relationship with the B-52, but not all of it at Minot. In fact, the squadron's first BUFFs – G models – arrived in 1959 when it was based at Travis AFB, California. The 69th BS has black tail stripes and is known by the nickname 'Nighthawks'.



Appendix C

NASA heavy lift air launch programme

NASA has been a B-52 operator since it received its NB-52A (52-0003) in 1959. The aircraft, the third example of the first 13 B-52As ordered by the US Air Force, had been modified by the addition of a pylon between the right inboard engine nacelle and the fuselage. This pylon facilitated the carriage and release of the North American X-15 rocket-powered aircraft, but did not allow adequate clearance between the X-15's tail and the B-52's inboard trailing edge flap. Accordingly, a 6ft x 8ft section was cut from the flap to prevent contact. Flight tests began in March 1959, during which the umbilicals that fed the X-15 hydrogen and liquid oxygen from tanks in the B-52's bomb bay were tested. The first actual launch occurred on 8 June that same year.

'003 was joined at NASA by NB-52B 52-0008, the tenth B-52, which was soon christened 'Balls 8' on account of its serial number. It featured the same X-15 modifications as its older brother, but while the NB-52A was retired to Pima County Air Museum, Arizona, ten years later in 1969, '008 would go on to have a distinguished career with NASA that lasted until 2004, a total of 45 years!

The NB-52B underwent a number of modifications, according to NASA: 'Installation of various pylons used to carry research vehicles and test articles to be air dropped occurred over the years. The pylons were attached under the right wing between the inboard engine pod and fuselage. Each pylon was subjected to extensive drag, airflow and loads testing before use ... Special instrumentation was installed to record and transmit test and research data and video to the Dryden Mission Control Room or other receivers during research missions.'

NASA said of Balls 8 that it 'participated in some of the most significant projects in aerospace history. At retirement, the air launch and research aircraft held the distinction of being NASA's oldest aircraft, as well as being the oldest B-52 on flying status.'

Amongst these 'significant projects', the NB-52 flew 140 X-15 missions, and another 19 'captive-carry' (ie no launch) X-15 flights. 'Between 1966 and 1975, B-52 008 was the launch aircraft for 127 of the 144 flights of wingless lifting body aircraft that contributed



LEFT One of three X-15 rocket planes from North American rests on Rogers Dry Lake, California, in September 1961, following a mission. NASA's NB-52B launch aircraft flies overhead. (NASA)



ABOVE AND BELOW
NASA's B-52B launch
aircraft takes off carrying
an X-43A hypersonic
research aircraft on
an evaluation flight.
The B-52, the oldest
still flying at the time,
was officially retired
from service during a
ceremony at Edwards Air
Force Base after nearly
50 years of dropping
advanced research
vehicles. (NASA)

to development of the space shuttles,' say NASA. And between 1977 and 1978, and once more between 1983 and 1985, Balls 8 was used to test and develop the parachute recovery system destined for use on the Space Shuttle's solid rocket boosters. Later, this workhorse of an airframe was used to test the drag chute deployment system being installed in NASA's Space Shuttle orbiters themselves: 'Tests were carried out at landing speeds ranging from 160 to 230mph on a lakebed runway and also on the main concrete runway at Edwards. They demonstrated the initiation, deployment, inflation, and overall operation of the orbiter drag chute system.

Data from the tests were used to validate predicted loads.' These weren't the first parachute tests that the NB-52B had been used for, though: from 1979 it had also tested the main parachute fitted to the General Dynamics F-111 crew escape module.

As Balls 8 entered its twilight years it remained as useful as ever. Using the same pylon that had been installed in 1959 for the X-15 programme, and with its right wing's trailing edge flap still notched, it carried aloft and launched the Pegasus rocket boosters, acted as the launch platform for the X-38 crew return module, and was the launch aircraft for NASA'S Hyper-X, scramjet-powered X-43A vehicle. Hyper-X was Balls 8's swansong project; on 17 December 2004 the aircraft was formally retired with only 2,443.8 hours of flight time logged, making it the lowest-time B-52 of the entire fleet. It is currently in non-flyable storage and will eventually be displayed at the main gate of Edwards AFB, California.

NASA continued to operate the Stratofortress post-Balls 8, and acquired a 'new' B-52H – 61-0025 – from the USAF's 23d BS, 5th BW, at Minot AFB in 2001. Upon receipt of the new BUFF, a flight research instrumentation package was installed onboard. However, a lack of heavy lift projects meant that the aircraft was largely superfluous to requirements and was therefore returned to its original owners at Minot in mid-2007.



Appendix D

Technical specification, B-52H

Crew: 5.

Length: 159ft 4in (48.5m).

Wingspan: 185ft (56.4m).

Height: 40ft 8in (12.4m); fin folded: 21ft 6in (6.5m).

Wing area: 4,000ft² (370m²).

Tread: Centreline outboard main tyres 11ft 4in (3.5m);

centreline tip gear to tip gear 148ft 5in (45.3m).

Aerofoil: NACA 63A219.3 mod root, NACA 65A209.5 tip.

Empty weight: 185,000lb (83,250kg).

Loaded weight: 265,000lb (120,000kg).

Maximum take-off weight: 488,000lb (220,000kg).

Power plant: 8 × Pratt & Whitney TF33-P-3/103 turbofans, 17,000lbf (76kN) per engine.

Fuel capacity: 47,975 US gallons (39,948 imperial gallons, 181,610 litres).

Drag area: 47.60ft² (4.42m²).

Wing aspect ratio: 8.56.

Performance

Maximum speed: 560kt (650mph, 1,047kph).

Combat radius: 4,480 miles (3,890nm, 7,210km).

Ferry range: 10,145 miles (8,764nm, 16,232km).

Best rate of climb: 4,100fpm at sea level (380,000lb at 295kt indicated).

Best range cruise speed: Mach 0.765 (heavy gross weight extension configuration).

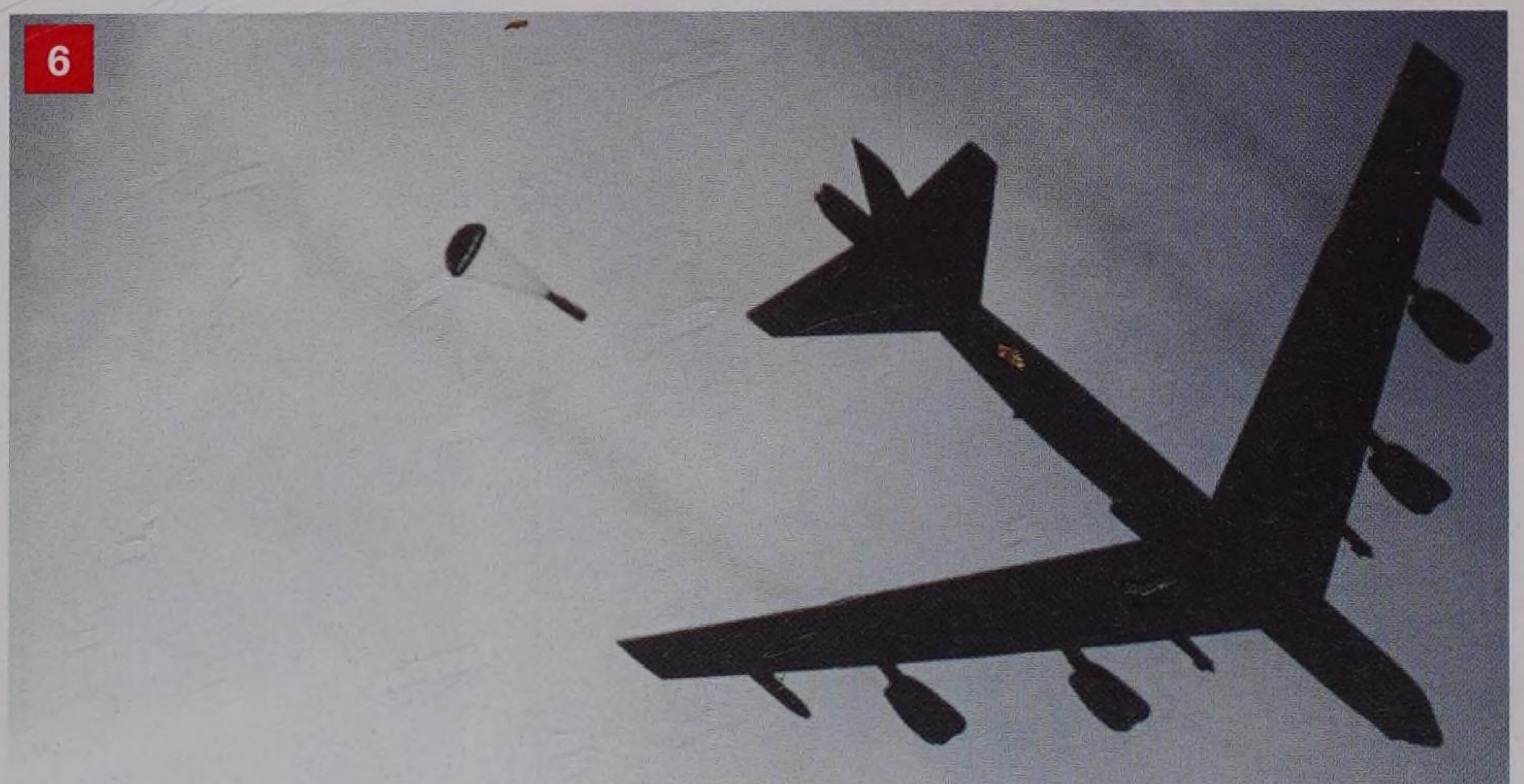
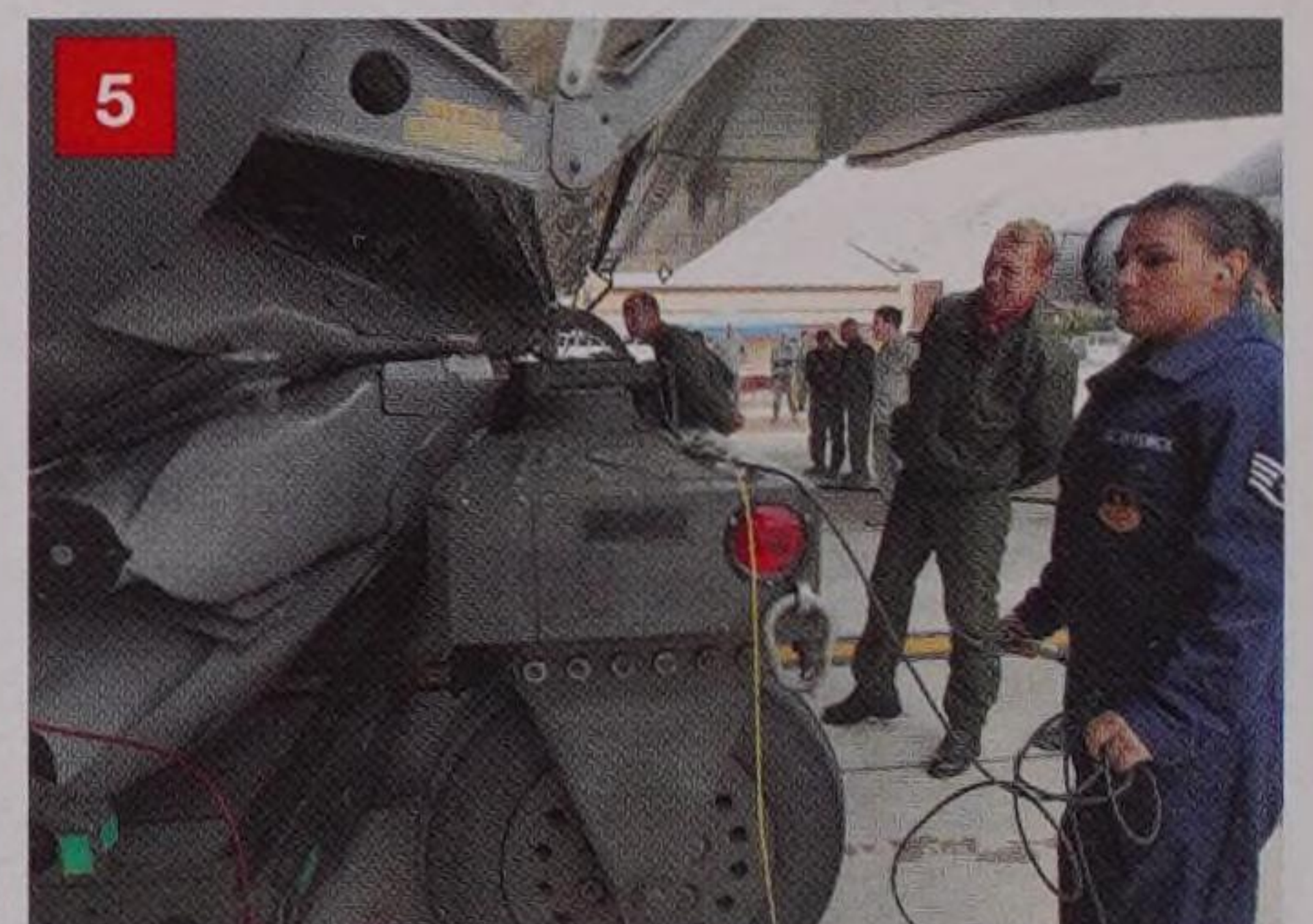
Service ceiling: 55,000ft (16,764m).

Rate of climb: 6,270fpm (31.85m/s).

Wing loading: 120lb/ft² (586kg/m²).

Thrust/weight ratio: 0.31:1.

Lift-to-drag ratio: 21.5:1 (estimated).



THIS PAGE A series of images depicting just some of the weapons cleared for release by the B-52H and its predecessors: [1] AGM-129 advanced ALCMs installed on an HSAB, [2] B-61 free-fall nuclear bombs in the internal bomb bay, [3] Mk84AIR retarded 2,000lb free-fall bombs from the bomb-bay, [4] SRAMs attached to a CSRL, [5] AGM-86 ALCMs installed on the CSRL, and [6] A Mk60 CAPTOR (encapsulated torpedo) anti-submarine mine. (USAF)

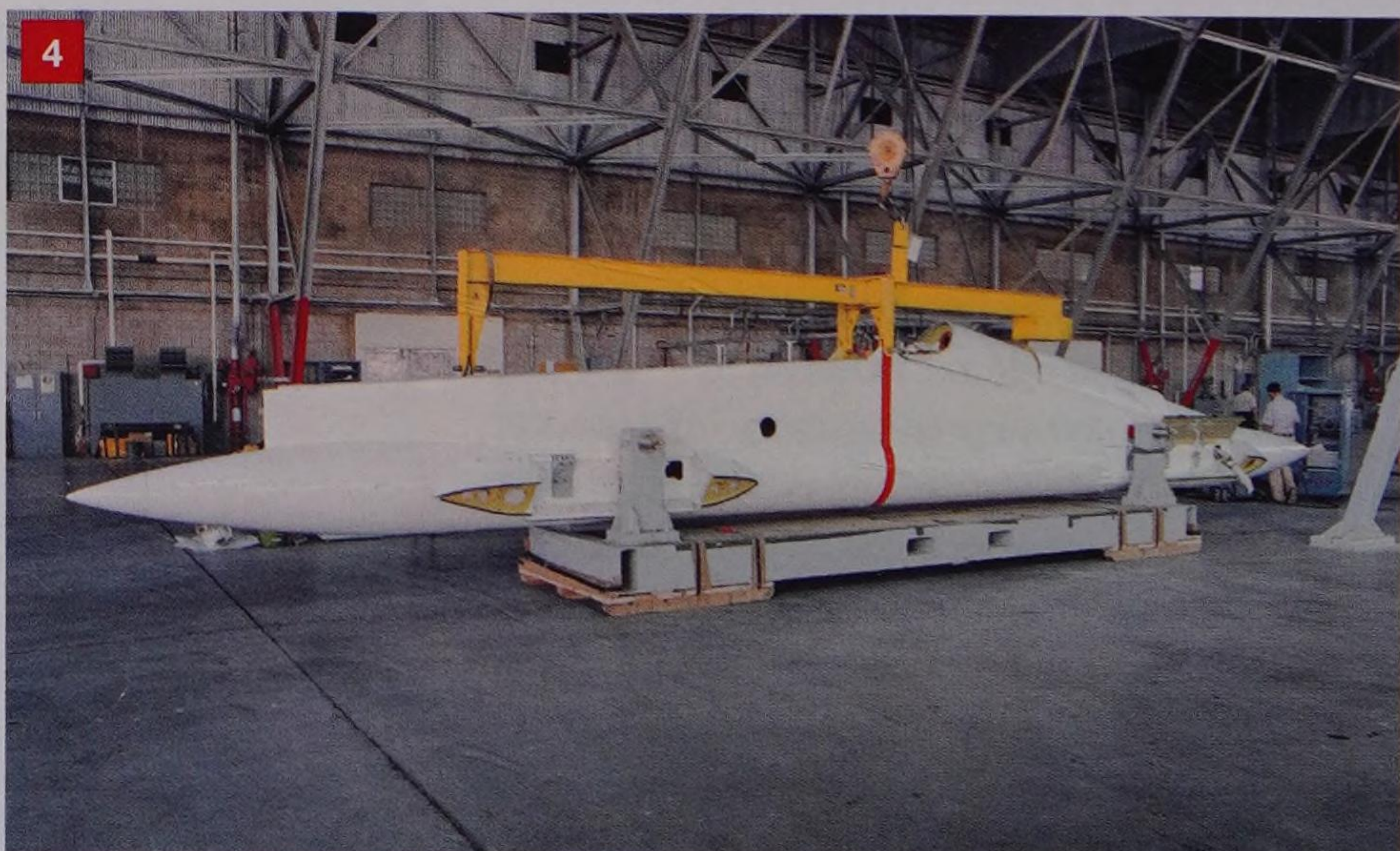
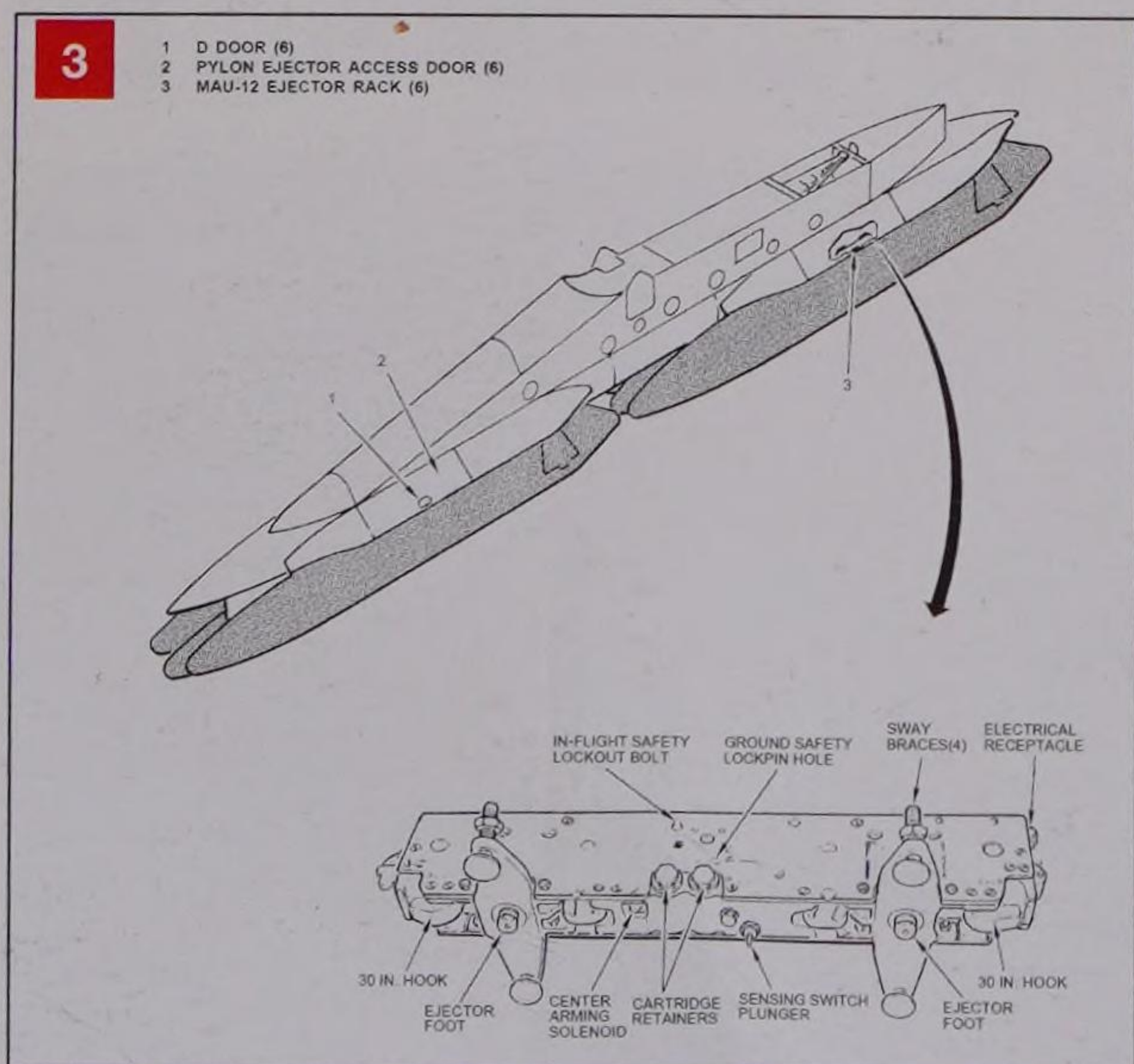
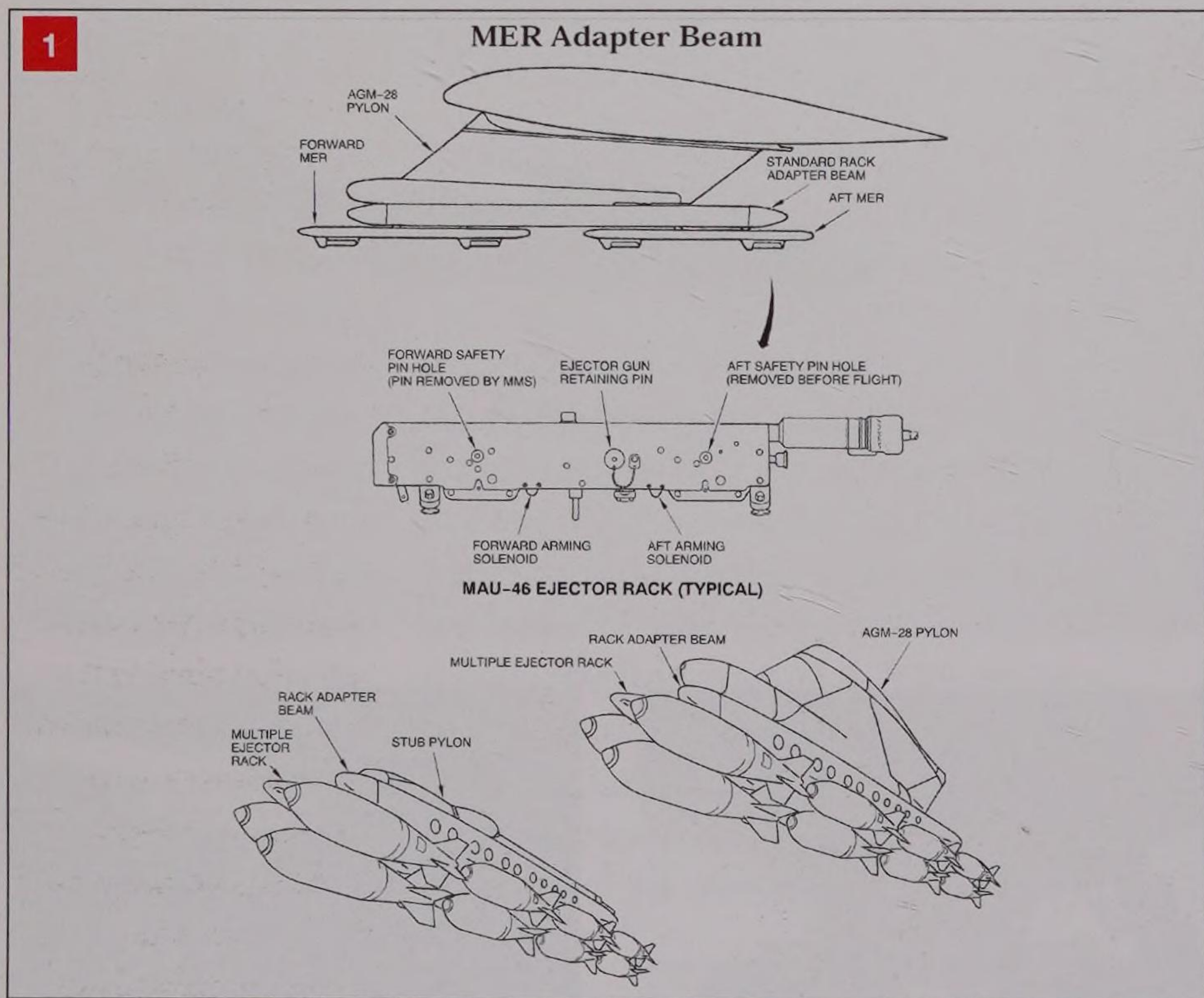
B-52H weapons carriage

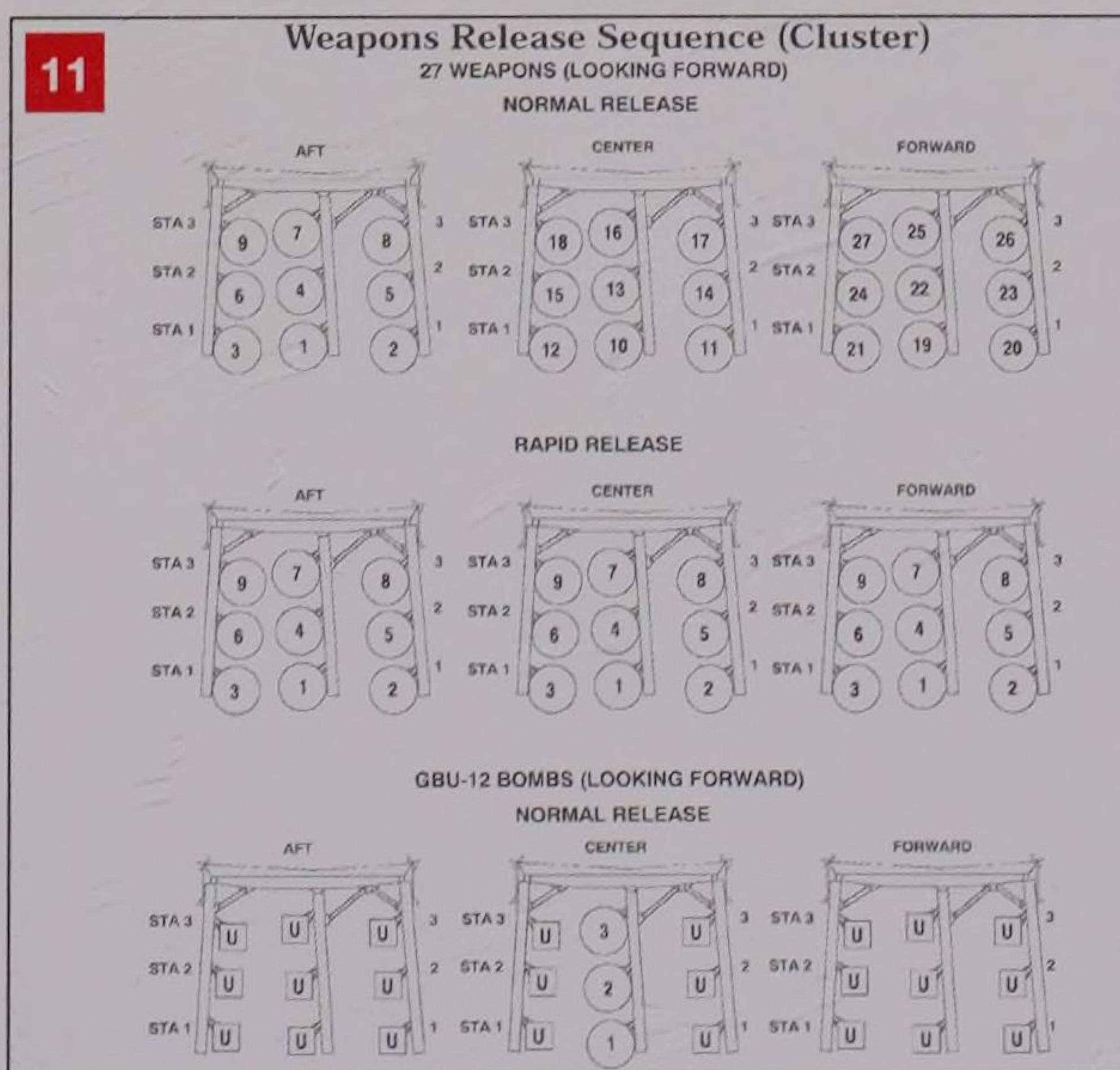
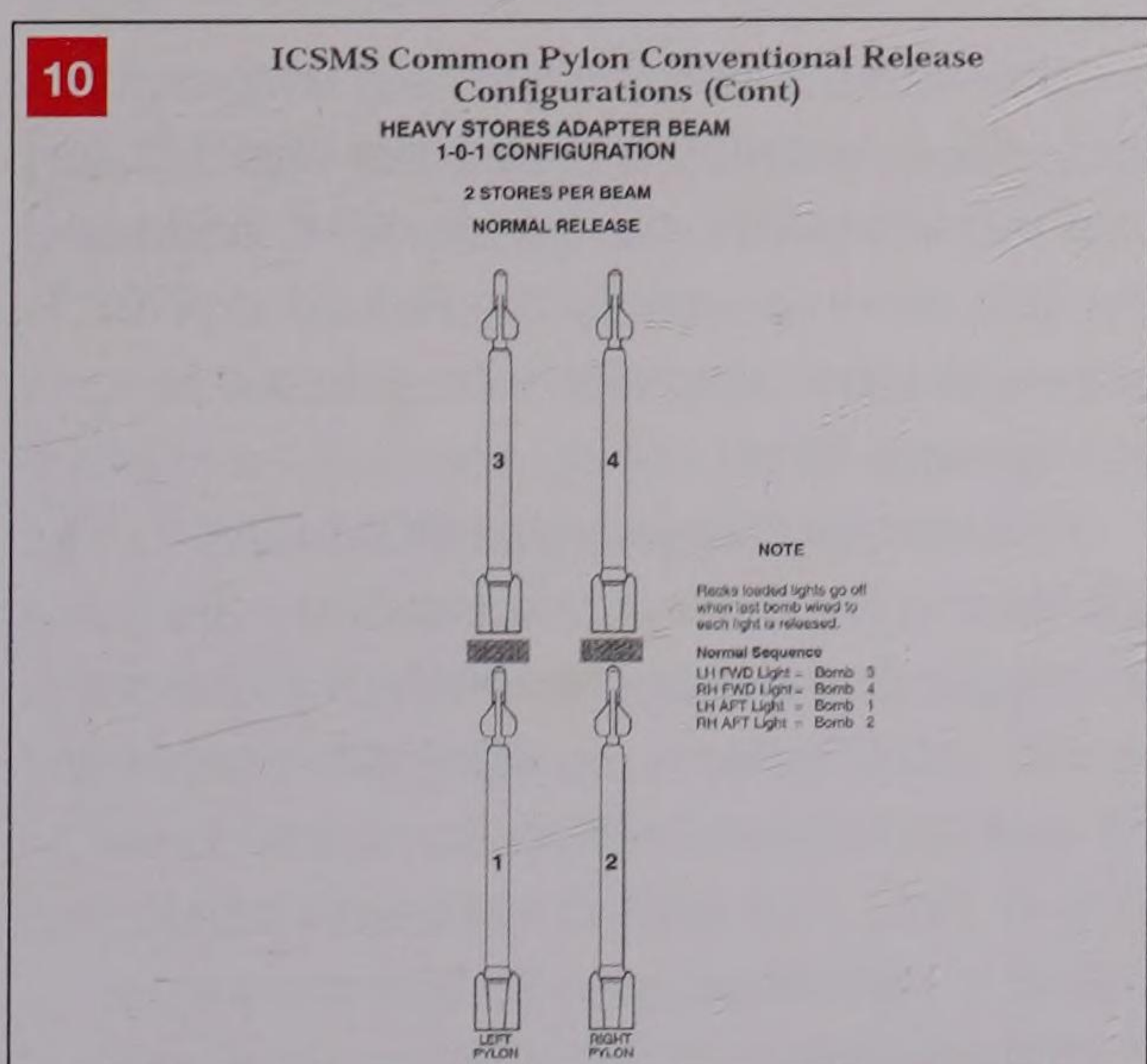
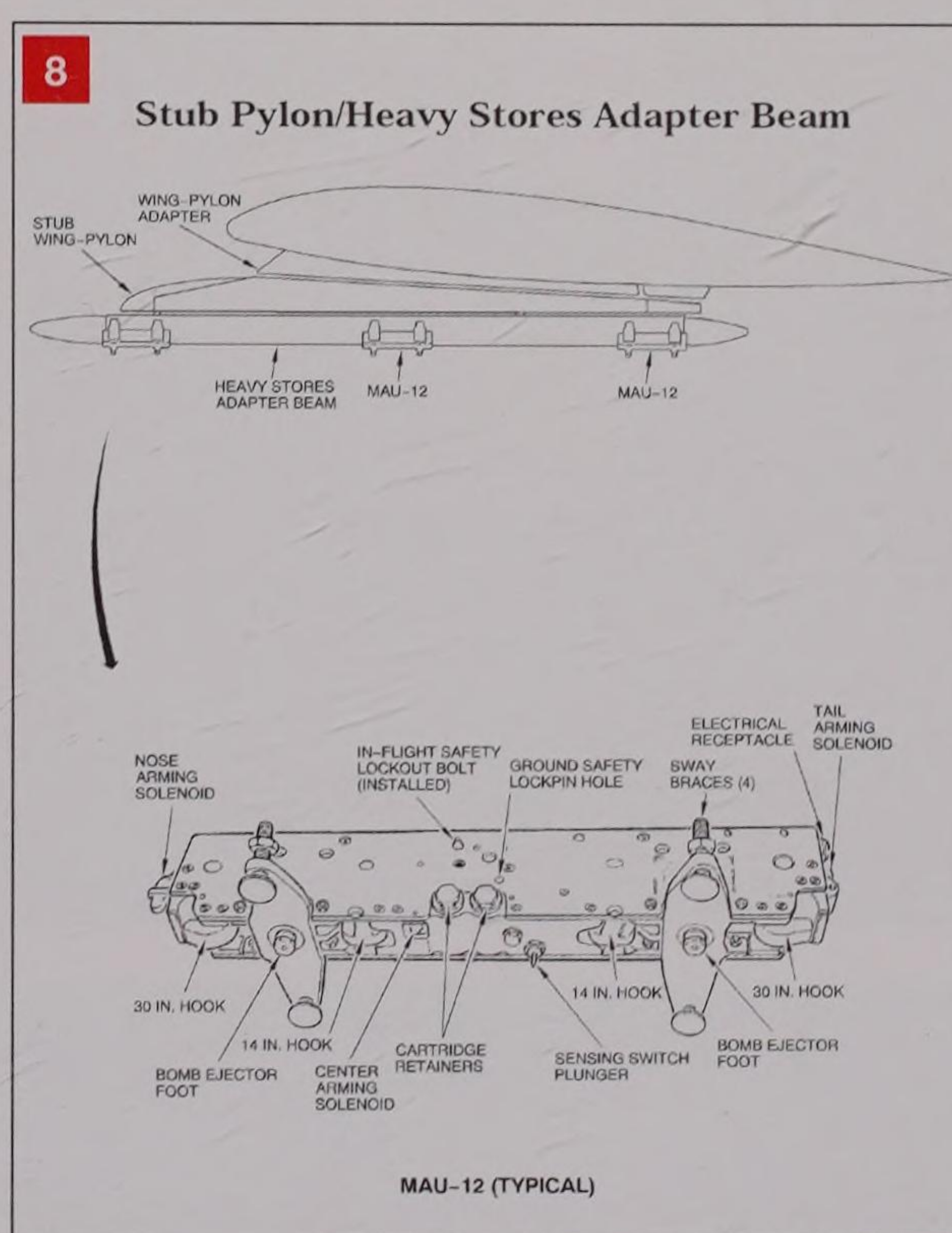
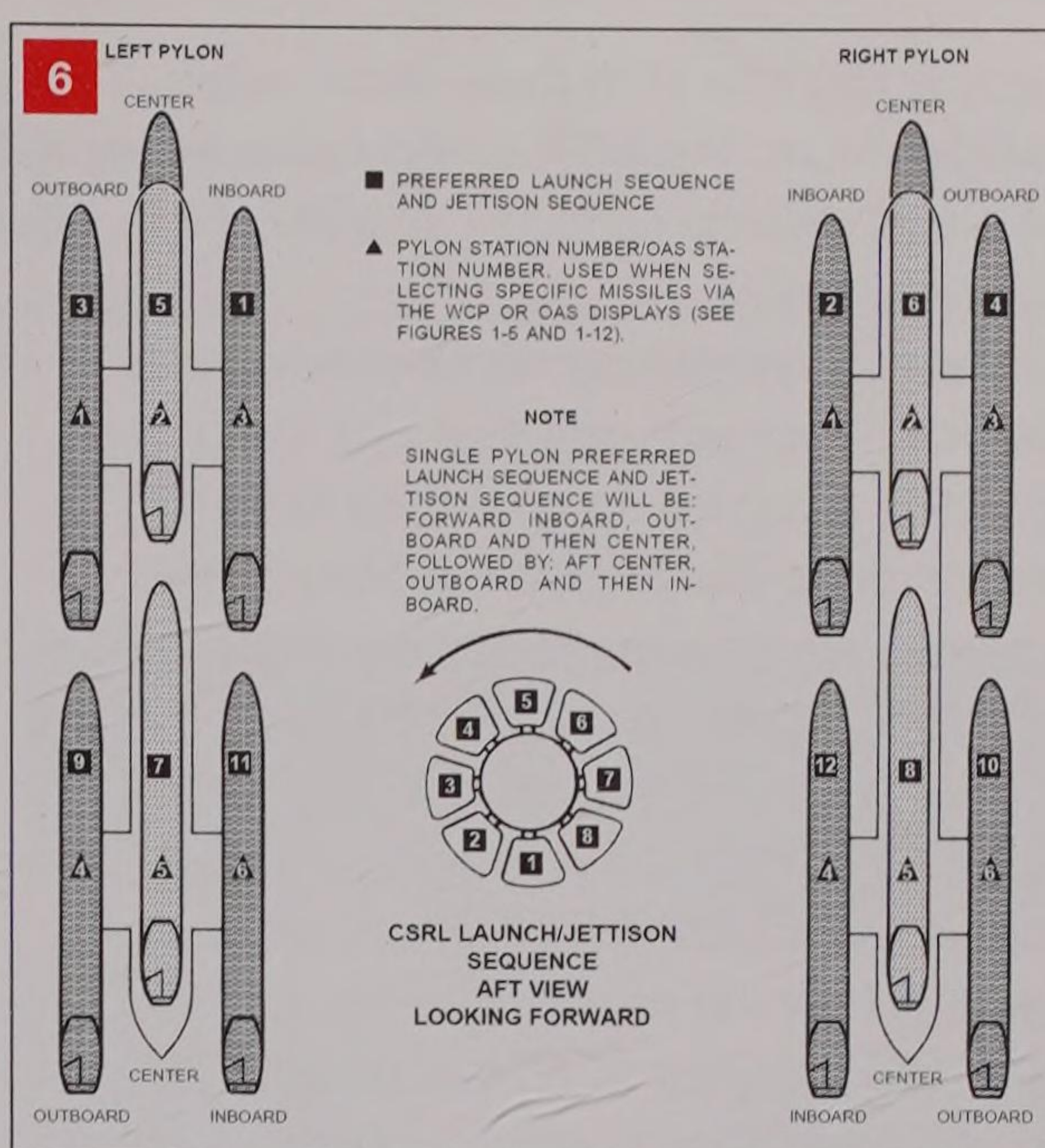
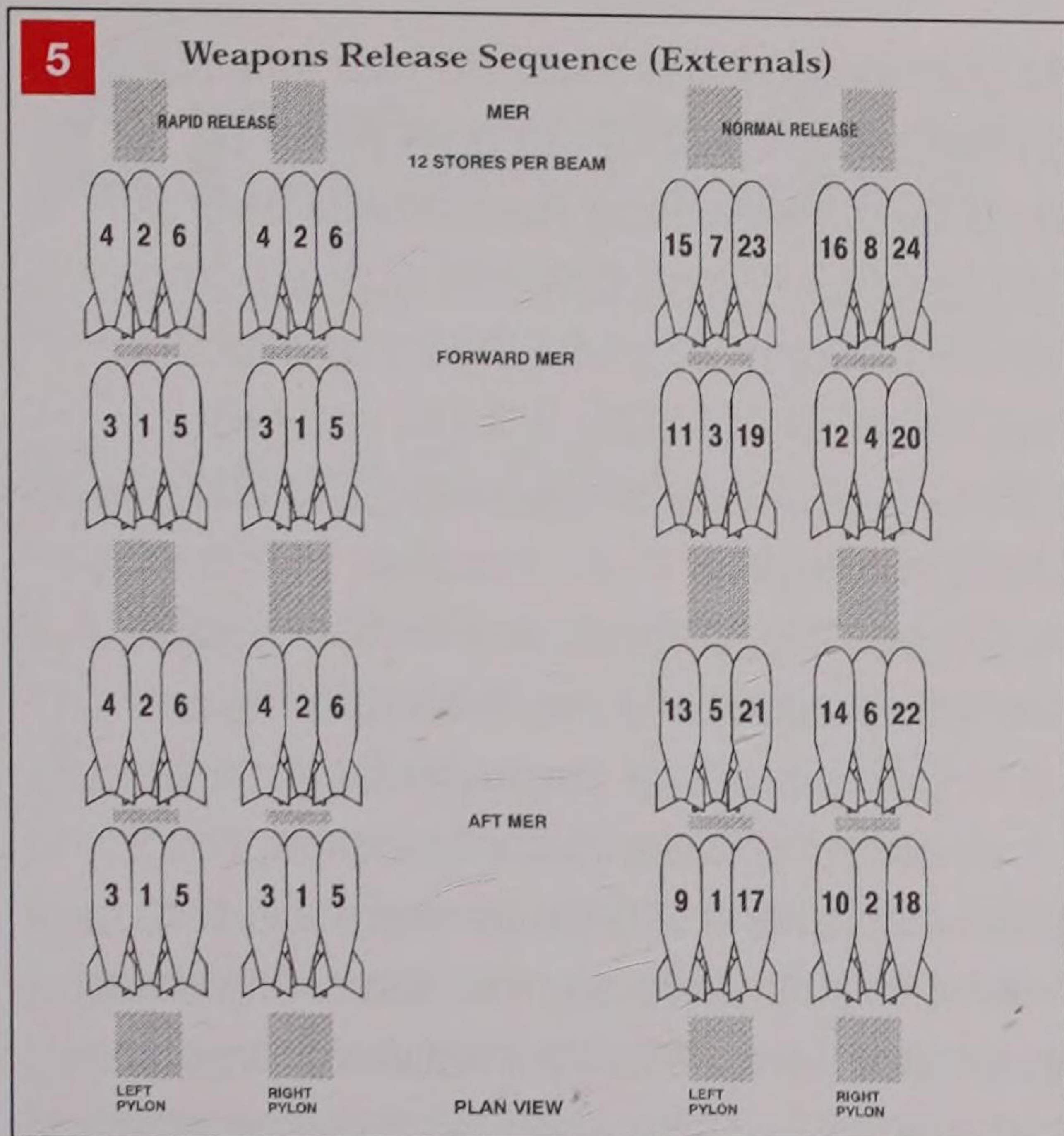
The B-52H can carry a varied weapons load amounting to approximately 70,000lb (31,500kg) of mixed ordnance. This is carried using an internal 'cluster rack' or the CSRL, and on external pylons.

Up to 12 cruise missiles may be carried externally on either a special cruise-missile pylon or a heavy stores adapter beam (HSAB), although common sense means that mixed loads of conventionally armed AGM-86C/D air-launched cruise missiles (CALCMs) with nuclear AGM-86B ALCMs or AGM-129 advanced cruise missiles is prohibited. The CSRL can carry up to eight AGM-86B/C/Ds, B-61s or B-83 gravity nuclear weapons,

although, once again, mixed loads are not permitted. Alternatively it can suspend a variety of conventional, free-fall gravity weapons either directly or mounted on up to three 'cluster rack' assemblies that provide for an internal carriage of up to 27 weapons in total.

External munitions are suspended in one of two ways. The first method uses a single AGM-28 Hound Dog pylon under each wing, each of which carries a maximum of six missiles. It is compatible with AGM-86 CALCMs, AGM-154 joint stand-off weapons, AGM-158 joint air-to-surface stand-off missiles and AGM-129 ACMs. Alternatively it can accept standard rack adapter beams that





Actually attaching ordnance to the B-52 requires a range of special adapters and pylons: [1 & 2] the multiple ejector rack, or MER, allows a range of conventional stores to be attached using MAU-46 ejector racks. The MER is attached to a standard rack adapter beam, which is in turn attached to an AGM-28 Hound Dog pylon [4]. The rapid release sequence from the MER is shown in [5]. Next, the common strategic rotary launcher [6] is mounted in the bomb bay and allows the rapid release of nuclear and non-nuclear missiles [7], in these examples AGM-86 CALCMs. The heavy stores adapter beam [8] is equipped with MAU-12 ejector racks [3], as shown here on an M-117-toting B-52H being prepared for an Operation Iraqi Freedom sortie [9]. Very heavy configurations – such as this load of four 5,000lb GBU-28 ‘Bunker Busting’ bombs – can be carried on the HSAB in pairs [10]. Finally, the internal bomb bay can carry an array of stores, the release sequence for which is given here [11]. (USAF)

support two sets of multiple ejector racks (MERs) in turn. The MER configuration allows for a total external carriage capability of 24 free-fall weapons.

The second method involves the use of one HSAB per wing attached to a stub pylon, providing mounting for up to nine MAU-12 ejector racks. Each HSAB therefore gives a total external carriage capability of up to 18 free-fall weapons (nine per HSAB, one per MAU-12). In addition, 16 CBU-103/105 WCMD cluster munitions (eight per pylon) can be carried, and 12 JDAMs weapons (six per pylon) can be carried when an ICSMS external pylon is attached to the HSAB. The HSAB is also used to employ missiles. Up to eight AGM-84D anti-ship missiles (four per HSAB) can be carried, and these may be released singly or in a salvo consisting of one from each wing. Similarly, up to two AGM-142 Have Nap surface attack guided tactical missiles can be carried on each HSAB. For this weapon, a data link pod is usually carried on one of the HSABs, reducing the total AGM-142 carrying capability to three. When four Have Naps are required to be employed by a single aircraft, a second B-52 carries the data link pod.

The free-fall weapons cleared for use by the B-52H include the low-drag general purpose (LDGP) series of Mk82 500lb and Mk84

2,000lb bombs; the Mk82 AIR (air inflatable retard) and Mk84 HD (high drag) bombs; M-117 750lb low drag bomb and M-117 AIR bomb; CBU-87 and CBU-89 cluster bombs; M-129 leaflet bomb; Mk55/56 sea mines; and the GBU-10C/D/E 2,000lb and GBU-12B/C/D 500lb series of laser-guided bombs. The variable-yield, thermonuclear B61 serves as the primary strategic and tactical nuclear free-fall weapon, and can be set to deliver up to 340 kilotons of explosive force. In its most common 'Mod 7' configuration, this parachute-retarded weapon weighs in the order of 700lb, although the 'Mod 11' version is hardened to penetrate reinforced targets and weighs 1,100lb. The B83 is the second nuclear free-fall weapon currently cleared for carriage by the B-52H. It has a maximum yield of 1.2 megatons and weighs 2,400lb.

B-52 legacy weapons

Legacy free-fall weapons for the B-52 family include British-made 1,000lb parachute bombs; Mk20 Rockeye II and CBU-52/58/71 cluster bombs; Mk82 SE 'Snake Eye' and M-117R high-drag bombs; M-117D 'Destructor' mines; ALE-25 chaff rockets (equipping the D/G/H models only); MJU-1B chaff bombs; and the 'Quick Strike' series of Mk62QS 500lb, Mk63QS 1,000lb, Mk64QS 2,000lb and Mk65 2,000lb mines.

Legacy nuclear free-fall bombs include the B28, B41 and the B53. The B28 was a lightweight thermonuclear weapon rated to about 1.45 megatons, while the B41 was the most powerful nuclear weapon ever built by the US – it weighed 10,670lb and had a yield of 25 megatons. The 8,850lb B53 bridged the two with a yield of nine megatons. The B28 was retired in 1991, the B41 in 1976, and the B53 was replaced by the B61-11 in 1997 (although some examples were retained in storage until 2011).

Two nuclear missiles – the AGM-69 SRAM and the AGM-28 Hound Dog – are also legacy weapons. The SRAM, which was retired in 1993, had a variable yield of between 17 and 210 kilotons and replaced the Hound Dog in 1978. The latter could be preset to deliver a yield of between 70 kilotons and 1.45 megatons.

BELOW A static display photograph showing just some of the ordnance that a single Stratofortress can carry. Noteworthy are the cluster munitions at the ends of the second row from the front. (USAF)



Appendix E

Modified B-52s

LAMS

The aircraft load alleviation and mode stabilisation (LAMS) project saw canard flight control surfaces and a bespoke flight control system fitted to a single B-52E. Its objective was to establish whether an advanced flight control system could reduce in-flight aerodynamic loads during a typical B-52 mission.

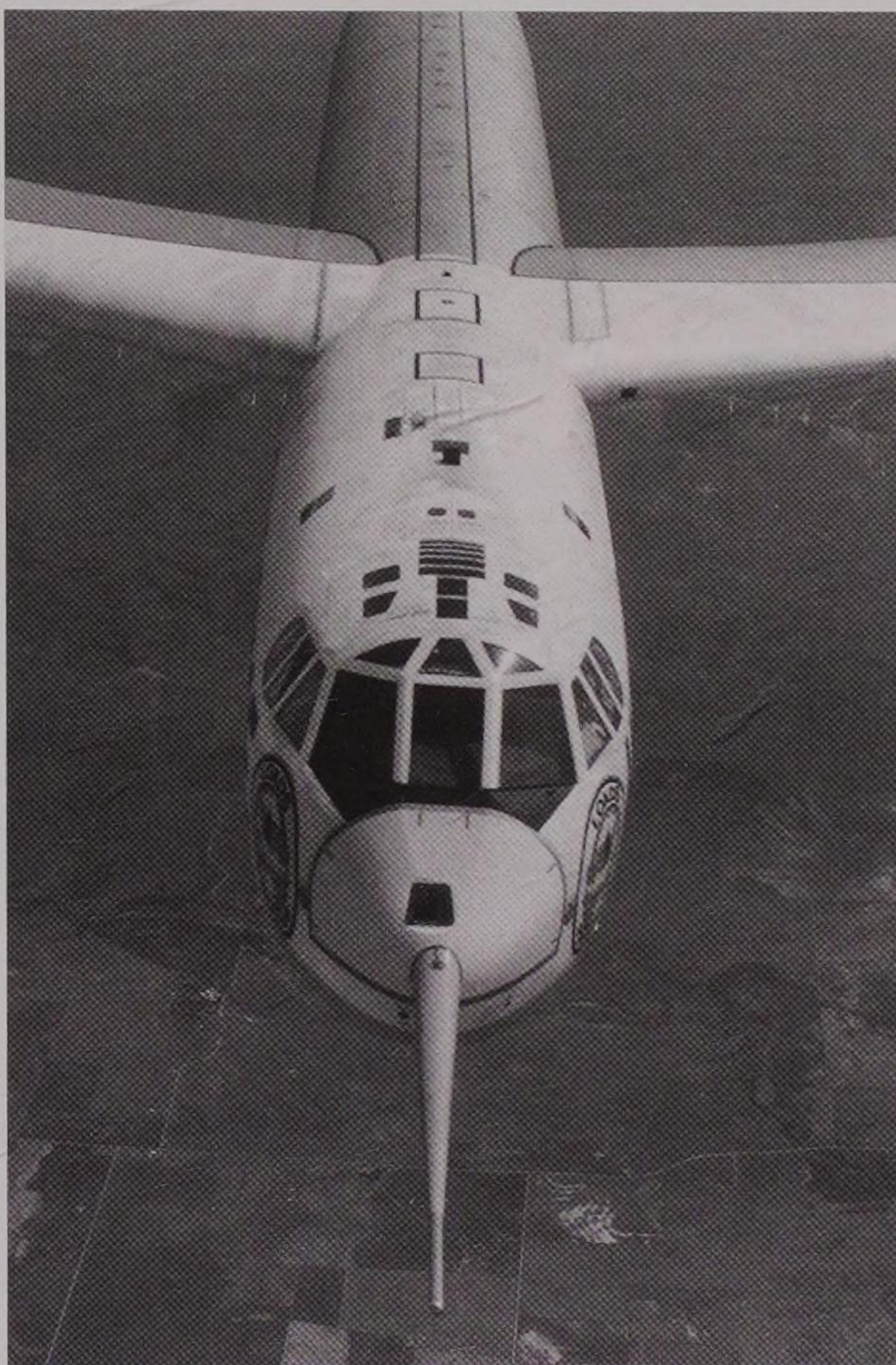
LAMS ran between June 1966 and December 1968, and, in addition to the LAMS canards, also saw B-52E 56-0632 fitted with a fly by wire (FBW) system at one of the pilot's stations, hydraulically powered flight controls, analogue computers and stations for test engineers. These changes resulted in the aircraft being redesignated an NB-52E, and reduced the amount of vertical and horizontal loads and vibrations, particularly in gusty conditions.

LAMS was a success in that it provided 'a comparison of analytical and experimental data. The results obtained showed that the LAMS-FCS provided significant reduction in fatigue damage rates', according to the original November 1969 report.

TF-39 BUFF

Another noteworthy Stratofortress is B-52E 57-0119, which was used in the 1960s by engine manufacturer General Electric to test the then-new GE TF-39 turbofan. The TF-39, a high bypass ratio engine that was to power the Lockheed C-5A Galaxy, was installed in place of the right inboard engine nacelle (replacing engines 5 and 6). Outputting 43,000lb of thrust, it had more than enough oomph to offset the loss of the two J57s, and actually dwarfed the B-52's three other nacelles. After the testing was complete, '119 met with an ignominious end: with no other testing work on offer, it was literally blown up at Edwards AFB, California, in order to comply with the SALT II treaty.

There were also other examples of incongruously engined B-52s. B-52A 52-0001



LEFT AND BELOW
The 'LAMS' BUFF,
more formally known
as the Boeing NB-52E,
participated in the Air
Force Flight Dynamics
Laboratory-Boeing
Control Configured
Vehicles programme.
(USAF)





tested engine improvements destined for the J57-P-43W engines of the B-52F. B-52E 56-0636 was used to test the Pratt & Whitney JT8D-200 and JT9D-59/70 engines, the latter of which was even bigger than the TF-39. Similarly, XB-52 49-0230 was used to test the J-75, this time mounted in place of the left outboard engine nacelle. Finally, B-52G 57-6471 was selected to test the TF-33 turbofan engines destined for the B-52H.

B-52D Big Belly

In contrast to the examples above involving modifications to single airframes, the 'Big Belly' modification was applied to a large number of the B-52D fleet between 1965 and 1968. It allowed the B-52D to carry an increased load of conventional munitions, making its 'carpet bombing' over North Vietnam more effective. Big Belly made it possible to carry 60,000lb of conventional munitions internally and externally, giving it a 22,000lb payload advantage over the B-52F. Whilst the B-52D external payload remained at 24 Mk82 free-fall bombs or M-117 750lb bombs, the internal capacity was increased from 27 Mk82s or M-117s to 84 Mk82s or 42 M-117s. Thus the Big Belly D model's maximum carriage of 108 bombs was an improvement of more than 100% over the F model's maximum load of 51 bombs.



LEFT AND ABOVE Officially designated the JB-52E, Stratofortress S/N 57-0119 conducts flight-testing of the then-new TF-39 engine. On the ground, the sheer size of the turbofan becomes readily apparent when compared to the two engines contained in the right-outboard engine pod. (USAF)

Appendix F

B-52 SIOP

For the B-52 crews, the Single Integrated Operating Plan manifested itself as a 'target folder' that each crew would study in secrecy, and which contained primary and secondary targets that they were tasked against. Should the nuclear 'Go codes' be received in an 'Emergency Action Message' and subsequently authenticated by the pilot and radar navigator, these were the targets to be struck. It was expected of each crew that, once the authentication criteria were met, they would unfailingly strike their target without further instruction.

Strict compartmentalisation of the SIOP meant that each crew knew only of the target they were assigned to strike, thus ensuring that only very senior military leaders and a handful of politicians knew the overall plan.

The SIOP target folders consisted of maps, photographs, satellite images and even radar imagery of the assigned targets, but it was for each crew to work together to create the actual plan of attack. The B-52's pilots and navigators would need to decide the best ingress and egress routes to the target, while the radar navigator would conduct a radar interpretation exercise whereby he would visualise, or in some

cases hand-draw, what he expected to see on his radarscope as the aircraft progressed along its track. Not least of all, he would cross-check the maps provided to establish where offset markers (bridges, islands, large buildings, coastlines – anything with a prominent or distinct radar return) might help with navigation or locating the target itself. Meanwhile, the EW officer would analyse the threat systems that protected the target, anticipating which would represent the gravest danger and how to counter them. The final member of the B-52 crew, the aerial gunner, would be expected to anticipate where Russian or Soviet fighters might intercept the flight, and plan accordingly.

SIOP ran from 1961 until 2003, during which time the B-52 was on continuous SAC alert until September 1991, at which point SAC became Air Combat Command. The airborne alert flights were terminated in 1968. At the height of the Cold War more than 16,000 targets were covered by the plan, most in the Soviet Union, though some were located in China and other nations who had the capacity to do grievous harm to the United States. By the end of 2001 that number had shrunk dramatically to a reported 2,500 targets.



LEFT When originally conceived and developed, the B-52 was to penetrate Soviet airspace at high altitude. The development of increasingly capable surface-to-air missiles put an end to that plan, forcing the B-52 to attack at low altitude. Here, a B-52G does just that. (USAF)

Appendix G

B-52 world records (Source: Boeing)

25 November 1956

Operation Quick Kick: Four B-52Bs of the 93d Bomb Wing and four B-52Cs of the 42d Bomb Wing completed a 16,000-mile (25,745km) non-stop flight around the perimeter of North America. The flight required four in-flight refuellings and included a pass over the North Pole.

16 January 1957

Three B-52Bs of the 93d Bomb Wing flew non-stop around the world. With the help of several in-flight refuellings, the bombers covered the 24,325-mile (39,139km) route in 45 hours and 19 minutes, halving the previous record. Average speed was 530mph (853kph).

17 November 1957

Six B-52s flew non-stop from the United States to Buenos Aires, Argentina, and back. Average speed for the 10,600-mile flight was 560mph (901kph). This was the first time B-52 jet bombers teamed up with the Boeing KC-135 jet tankers for an actual long-range refuelling mission.

11 January 1962

A B-52H set a new straight-line distance record by completing a non-stop, unrefuelled flight

from Okinawa, Japan, to Madrid, Spain. The aircraft was flown by a 15th Air Force crew from the 4136th Strategic Wing based at Minot Air Force Base, North Dakota. The flight lasted 21 hours and 52 minutes and covered 12,519 miles (20,143km).

1 November 1963

In a test flight with a Boeing Wichita crew, a B-52H remained in the air for 26 hours and 26 minutes as it flew 12,400 miles (19,950km) round the entire outline of the continental United States. At the time, the flight was the longest by a Boeing crew. The purpose of the test flight was to provide data on loads and stress exerted on the aircraft during high-altitude, long-endurance missions.

16 January 1991

Air operations in support of Operation Desert Storm during the Gulf War began when seven B-52Gs took off from Barksdale Air Force Base, Louisiana, and headed for Iraq. After hitting their targets, the B-52s returned to Barksdale. The flight covered more than 14,000 miles (22,500km) with the planes remaining in the air for 35 hours, making it the longest air-combat mission in history at that time.

BELOW With the gear coming up and water injection giving a much needed take-off boost, another B-52G takes to the skies during Operation Desert Storm. (USAF)



Appendix H

B-52 timeline (Source: Boeing)

The 1940s	
13 Feb 1946	The US Army Air Force issues basic requirements for a new long-range heavy bomber.
28 June 1946	Boeing awarded engineering study and preliminary design contract for turboprop-powered B-52 bomber.
25 Oct 1948	Boeing presents the Air Force with a proposal for B-52s powered by eight jet engines.
26 Jan 1949	The Air Force informs Boeing that work can proceed on two experimental, jet-powered B-52s under the original contract.
The 1950s	
15 April 1952	YB-52 prototype makes first flight in Seattle.
28 Sept 1953	Boeing's Wichita plant announced as second source for B-52 production.
5 Aug 1954	B-52A first flight.
25 Jan 1955	B-52B first flight.
29 June 1955	First B-52B for the Air Force's Strategic Air Command is delivered to 93d Bomb Wing at Castle AFB, California.
9 March 1956	B-52C first flight.
14 May 1956	First Wichita-built B-52, a D model, makes first flight.
28 Sept 1956	First Seattle-built B-52D makes first flight.
6 Dec 1956	B-52 wins National Aeronautic Association's Collier Trophy for 1955.
18 Jan 1957	Three B-52Bs fly around the world in 45 hours and 19 minutes, averaging 530mph over the 24,325-mile course. This cuts the previous record in half.
3 Oct 1957	B-52E makes first flight in Seattle.
17 Oct 1957	B-52E makes first flight in Wichita.
6 May 1958	B-52F makes first flight in Seattle.
14 May 1958	B-52F makes first flight in Wichita.
27 Oct 1958	B-52G makes first flight in Wichita.
25 Feb 1959	Last Seattle-built B-52, an F model, is delivered.
23 April 1959	First test flight of North American Aviation's AGM-28A Hound Dog supersonic air-to-surface missiles from B-52.
17 Sept 1959	NASA's X-15 research rocket plane makes its first powered flight, carried aloft and released from an NB-52A.
The 1960s	
Feb 1960	The McDonnell Aircraft GAM-72 Quail decoy missile goes into service on B-52Gs at Eglin AFB, Florida.
16 March 1961	B-52H makes first flight in Wichita.
9 May 1961	First B-52H is delivered to 379th Bomb Wing at Wurtsmith AFB, Michigan.
26 Oct 1962	Last B-52 (B-52H, tail number 61-040) is delivered by the Wichita plant to the 4136th Strategic Wing at Minot AFB, North Dakota.
18 June 1965	Strategic Air Command B-52s strike targets in Vietnam for the first time.
The 1970s	
15 Sept 1972	Boeing AGM-69A short-range attack missiles, or SRAMs, become operational on B-52s with the 42d Bomb Wing at Loring AFB, Maine.
18 Dec 1972	Staff Sergeant Samuel Turner becomes the first B-52 gunner to shoot down an enemy aircraft when he hits a North Vietnamese MiG-21 during Operation Linebacker II.
24 June 1973	Delivery of first B-52H with electro-optical viewing system (EVS) to enhance vision when flying at low level at night.
15 Aug 1973	Strategic Air Command B-52s fly final mission in South-East Asia.

21 Feb 1974	Delivery of first B-52H equipped with Phase VI electronic countermeasures (ECM), to upgrade defensive avionics system.
7 Dec 1979	First B-52G arrives in Wichita to receive computer-controlled offensive avionics systems (OAS) upgrade.
The 1980s	
11 Jan 1981	First Boeing AGM-86B air-launched cruise missiles (ALCMs) are delivered for carriage on B-52G under-wing pylons.
10 June 1982	Strategic Air Command's first all-female KC-135 Stratotanker crew refuels a B-52 during a five-hour training mission.
30 June 1985	McDonnell Douglas AGM-84D Harpoon anti-ship missiles are added to 30 B-52Gs.
30 June 1987	The AGM-129A advanced cruise missile (ACM) is added to B-52 arsenal.
Jan 1988	Boeing AGM-86C conventional air-launched cruise missiles (CALCMs) declared operational on B-52Gs.
The 1990s	
16 Jan 1991	Operation Desert Storm air operations begin when seven B-52Gs take off from Barksdale AFB, Louisiana, and head for the combat zone. After hitting targets in Iraq, the B-52s return to Barksdale, thus flying the longest air combat mission in history up to that time. The mission also sees first combat use of CALCMs.
Sept 1991	Strategic Air Command's B-52 ground nuclear alert status is ended.
1 Oct 1991	B-52 gunner position eliminated.
30 Sept 1992	The Boeing common strategic rotary launcher (CSRL) integration modification is completed for B-52H fleet. The launcher is fitted inside the bomb bay and can carry up to eight AGM-86 cruise missiles.
15 Feb 1994	Boeing Wichita receives initial development contract to integrate precision-guided munitions (wind-corrected munitions dispenser and joint direct attack munition) on B-52Hs.
16 May 1994	Due to retirement of the B-52G, the 'Rapid Eight' modification programme begins to provide the B-52H with guided-missile capability.
24 Aug 1994	Start of Conventional Enhancement Modification (CEM) programme. This gives the B-52H fleet capability for delivery of a new generation of precision-guided conventional weapons. Included in the upgrade is a global positioning system.
8 March 1995	B-52H successfully launches AGM-142A Have Nap electro/optical guided missile.
25 July 1995	The first live firing of Harpoon missile from B-52H using the Harpoon aircraft command launch control set (HACLCS).
3 Sept 1996	Operation Desert Strike sees B-52 missions flown in support of the larger US and Coalition effort called Operation Southern Watch.
Sept 1998	Joint direct attack munition (JDAM) is declared operational for use on B-52H. JDAM uses global positioning system for precise hits on aim points.
24 March 1999	B-52Hs open NATO's air campaign in the Balkans (Operation Allied Force) by launching CALCM cruise missiles at military targets throughout Yugoslavia. Later the bombers transition to delivering general-purpose weapons on Serbian army positions and staging areas.
June 1999	Wind-corrected munitions dispenser (WCMD) declared operational for use on B-52H. WCMD uses a tail kit attached to a cluster bomb unit to adjust the bomb's flight path for wind changes.
23 Dec 1999	The B-52H Avionics Midlife Improvement (AMI) programme is initiated to modernise offensive avionics processors and navigation systems on the Stratofortress.
21st century	
1 April 2000	Situational Awareness Defensive Improvements (SADI) programme is initiated to upgrade defence systems for the B-52H fleet.
7 Oct 2001	B-52H bombers take part in initial air attacks of Operation Enduring Freedom. The B-52H arsenal included JDAM and WCMD precision-strike weapons, AGM-142 Have Nap guided missiles, GBU-28 laser-guided bombs and Mk82 general-purpose bombs. The B-52s were the first to use the WCMD in combat. They also participated in psychological warfare operations using their M129 leaflet dispensers.
Nov 2001	AGM-86D CALCM Penetrator is declared operational on the B-52H. Its penetrating warhead allows the missile to destroy buried or reinforced targets from stand-off ranges of hundreds of miles.
31 Jan 2002	B-52 nominated for National Aeronautic Association's 2001 Collier Trophy.
15 April 2002	50th anniversary of first B-52 flight.

Glossary

- AAA** – Anti-aircraft artillery.
- AC** – Alternating current; also aircraft commander.
- ACC** – Air Combat Command.
- ACU** – Avionics computer.
- ADI** – Attitude director indicator.
- AEG** – Air Expeditionary Group.
- AFB** – Air Force Base.
- AFCS** – Automatic flight control system.
- AFRES** – Air Force Reserve.
- AFSAT** or **AFSATCOM** – Air Force satellite communications system.
- AGL** – Above ground level.
- AHRS** – Attitude heading reference system.
- ALCM** – Air-launched cruise missile.
- AMC** – Air Materiel Command.
- AMI** – Avionics Midlife Improvement programme.
- ATIS** – Automatic terminal information service.
- BDU** – Bomb dummy unit.
- BS** – Bomb Squadron.
- BW** – Bomb Wing.
- CALCM** – Conventional air-launched cruise missile.
- CAS** – Close air support.
- CEM** – Conventional Enhancement Modification programme.
- CSRL** – Common strategic rotary launcher.
- DC** – Direct current.
- DFCS** – Defensive fire control system.
- ECM** – Electronic countermeasures.
- ECP** – Engineering Change Proposal.
- ELINT** – Electronic intelligence.
- EPR** – Engine pressure ratio.
- EVS** – Electro-optical viewing system.
- EW** – Electronic warfare.
- EWO** – Electronic warfare officer.
- FCS** – Flight control system; also fire control system.
- FCP** – Flight computer program.
- FLAS/CG** – Centre of gravity/fuel level advisory system.
- FLIR** – Forward-looking infrared set.
- FMS** – Flight management system.
- fpm** – Feet per minute.
- fps** – Feet per second.
- FRL** – Fuselage reference line.
- FVR** – Flight vector reference.
- GEANS** – Gimballed electrically suspended gyro airborne navigation system.
- GPS** – Global positioning system.
- HBW** – Heavy Bombardment Wing.
- HSAB** – Heavy stores adapter beam.
- IAF** – Initial approach fix.
- ICSMS** – Integrated conventional stores management system.
- IEU** – Interface electronic unit.
- IFF** – Identification friend or foe.
- IFR** – In-flight refuelling.
- ILS** – Instrument landing system.
- IMU** – Inertial measurement unit.
- IR** – Infrared.
- JDAM** – Joint direct attack munition.
- KIAS** – Knots indicated airspeed.
- MER** – Multiple ejector rack.
- MFD** – Multi-function display.
- MRT** – Miniature receive terminal.
- NATO** – North Atlantic Treaty Organisation.
- NFZ** – No-Fly Zone.
- nm** – Nautical mile.
- OAS** – Offensive avionics suite.
- ODS** – Operation Desert Storm.
- OIF** – Operation Iraqi Freedom.
- ONW** – Operation Northern Watch.
- OSW** – Operation Southern Watch.
- QRC** – Quick Reaction Capability programme.
- RBS** – Radar bomb scoring.
- RO** – Response option.
- SAC** – Strategic Air Command.
- SALT** – Strategic Arms Limitations Treaty.
- SAM** – Surface-to-air missile.
- SAS** – Stability augmentation system.
- SIOP** – Single Integrated Operational Plan.
- SMO** – Stores management overlay.
- SPN** – Standard precision navigation.
- SRAM** – Short-range attack missile.
- STV** – Steerable television set.
- TA** – Terrain avoidance.
- TACAN** – Tactical air navigation.
- TR** – Transformer-rectifier.
- TTG** – Time to go, *ie* time to release of bomb(s), measured in seconds.
- USAF** – United States Air Force.
- VOR** – VHF omni-directional radio.
- WCMD** – Wind-corrected munitions dispenser.

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BOEING B-52 STRATOFORTRESS



1952 onwards (all marks)

RIGHT: It was during Operation Enduring Freedom that the B-52H Stratofortress first saw its combat debut. Here, a 457th Air Expeditionary Group B-52H takes to the skies on that very mission. (USAF)

against the Coalition forces on the ground, meaning that air support remains a critical element of ongoing operations. As such, the Air Force's B-52s maintain a steady deployment rate in support of Enduring Freedom at the time of writing (August 2012).

Gulf War II – Operation Iraqi Freedom

On the night of 21 March 2003, Operation Iraqi Freedom (OIF) began. For more than a decade a belligerent Saddam Hussein had tested the patience of the West, but now the governments of the United States and the United Kingdom decided that enough was enough. OIF was planned to deliver a bombardment of such ferocity that the opening phase was commonly referred to as 'Shock and Awe'. Quite how shocking and awe-inspiring it actually was is a matter of opinion, but many of the precision strikes that illuminated the Baghdad skyline that night are attributable to the more than 100 AGM-86CJs released by B-52s of the 2nd Bomb Wing. The Wing's 93rd BS split into two deployments – one to Diego Garcia, the other to RAF Fairford – which were tasked to deliver command and control targets. In five months they would fly more

RIGHT: Desert tan flight suit with patches removed and a draped Stars and Bars flag over the instrument console indicate that this 2003 photograph was taken on either an Operation Iraqi Freedom or Enduring Freedom sortie. Today, the B-52 is in as much demand as ever. (USAF)

than 100 combat sorties and drop greater than 1,000,000lb of munitions. Amongst these was the AGM-86C, a version that replaced the latest fragmentation warhead of the AGM-86C with a penetrating warhead, and was now making its combat debut.

Meanwhile, the 5th BW deployed approximately 500 people and 14 B-52s, scoring 1,600 combat flying hours during 120 combat missions. The Wing dropped 3,000,000lb of munitions, including CALCMs, JDAMs, laser-guided bombs and laser-guided bombs. Importantly, the Wing also made history when it employed the AGM-28 Lightning II target pod to strike targets at an Iraqi airfield on 11 April 2003. The arrival of the pod completed the B-52's precision engagement capability, as it allowed the aircraft to use its own laser-guided weapons on to precision targets. For the first time in its half-century history, the B-52 could now also autonomously search for, identify, target and engage moving targets on the ground.

The Asia-Pacific region

While not a combat operation, the B-52 does maintain a continuous bomber presence in the Asia-Pacific region in order to deter hostile acts against America's allies in the region, most notably by North Korea, but also by China. Andersen AFB on the island of Guam acts as home to this ongoing bomber rotation. While all B-52 squadrons support this mission, the 90th BS has assumed full-time responsibility for it since early 2007 when it completed its first deployment in support of Operation Enduring Freedom in order to do so.

LEFT: Closing up to the boom of a KC-135, the B-52H's aircrew commander gently eases the throttles to achieve the desired rate of closure. The tanker crew quite proudly tell all who will listen: 'No tanker gas', a phrase that is acronymised to NAKTANK. (USAF)

ABOVE: The crosswind crab system, a triumph of engineering design even today, gives the B-52 the crosswind performance envelope needed to make it a potent strategic bomber. Steering relays control the flow of hydraulic fluid to the steering actuators in order to align the main landing gear with the runway. (USAF)

The forward main landing gear is steered by hydraulic pressure controlled by movement of the rudder pedals. The pedals move mechanical and cable linkage through a ratio selector unit set by the pilots for one of two conditions: a 'taxi rate' allows the forward gear to be turned to a maximum angle of 60° right or left of centre, and a 'take-off and landing rate' restricts the turning angle to approximately 12° right or left of centre.

The crosswind crab system represented a feat of engineering at the time of the B-52's creation and was considered so advanced that it was classified during the early years of the aircraft's operational career. It reduces the hazards associated with crosswind take-offs and landings, turning at four main gear to align with the runway while the aircraft is down wings level to compensate for drift. The system allows the steering actuators on the front and all main gear, allowing the pilots to dial in a preset gear deflection of a maximum of 20° left or right during the approach. At 20° crab angle, landing in crosswinds as high as 43kt blowing 90° to the runway can be achieved, although a maximum landing weight of 270,000lb must first be reached. The pilots use the 'crosswind crab control knob' on the side stand to mechanically control the steering relays valves on each main gear. On landing, the pilots quickly centre the gear by means of a centring button or by turning the control knob to its centre position. On take-off, the system automatically centres

LEFT: The B-52's crosswind crab system was at one time considered so advanced that it was classified secret. Key to allowing the nuclear bomber to fly in crosswind conditions that would keep lesser designs grounded, the system is controlled via the large crosswind crab control dial on the side stand. (USAF)

when the landing gear lever is moved to the 'gear up' position.

Each wheel of the main landing gear has segmented rotor, multiple-disc hydraulic brakes with centrifugal brake linings. These activate in accordance with pressure on rudder pedals. While differential braking is not possible, an anti-skid system monitors and corrects skidding for each wheel. It optimises braking and prevents skids at high speed under light wheel loads, resulting in shorter stopping distances even in the wet. Brake pressure for the left and right wheels is supplied by the left and right body hydraulic systems respectively.

The two forward brakes are actuated simultaneously in turn, triggering the two rear brakes. Toe pressure applied by the pilots to the pedals is transmitted to two metering valves through mechanical linkages, and the pedals incorporate a spring system to create pedal feedback pressure. The side stand between the pedals features a parking brake to lock the pedals in the 'applied position' when the aircraft is at rest. It does so using pressure from the accumulators installed in the wheel well of each main wheel (one per wheel).

Finally, the B-52 pilots can deploy a 44ft-long ribbon-type drag parachute for deceleration during the landing roll. Installed in a compartment at the rear of the fuselage in the tail section, its operation is simple: the pilots move the drag chute lever from the 'locked' to the 'deploy' position, the compartment door opens, and a spring-loaded pilot chute is released into the airstream, thereby deploying the main parachute behind the aircraft as it does so. The risers of the main parachute are attached to the aircraft through a jettison mechanism; the lever's 'jettison' position releases the parachute for collection by ground crew.

Fuel supply, CG and refuelling systems

The B-52H can carry a total usable internal fuel load of 312,197lb. The main tanks are 'wet wing' integral wing tanks, each has four boost pumps and normally supplies two engines. Typically the engines receive fuel from the nearest four main tanks, but fuel can be supplied from any tank by means of a pressure override in the

ABOVE: With the gear lowered and locked, the pilots can manipulate the crosswind crab control knob on the centre side to rotate the main gear up 50° from the actual aircraft heading. Upon landing, the centring button is depressed to re-centre the gear with the aircraft fuselage. (USAF)

LEFT: A maintainer installs a freshly packed drag parachute whilst straddling the rear-most part of the tail section, left of the rudder. (USAF)

With a combat history spanning more than four decades, the USAF's B-52 Stratofortress is arguably the most successful combat aircraft of all time, setting world records throughout its half-century of operational use.

The B-52 evolved from a contract won by Boeing in 1945 to develop a turboprop-powered successor to the post-war Convair B-36 'Peacemaker'. The initial design featured a straight wing and six turboprop engines, but as the Air Force's requirements changed, jet power was specified, and the B-52 concept metamorphosed into what was effectively a new aeroplane, featuring swept wings and eight jet engines. The first flight of a B-52 finally took place in 1952, and the first aircraft entered service with the USAF in June 1955.

In a career that has seen this massive bomber transformed from a brute-force purveyor of World War 2-style carpet bombing to a modern strike aircraft using precision-guided munitions, the B-52 has been the most visible element of America's nuclear deterrent since its entry to service in June 1959. It has seen combat across multiple theatres, from south-east Asia to Afghanistan, the Balkans to Iraq. Today, it is the oldest aircraft in the United States' arsenal.

This manual provides a unique insight into the design, evolution, operation and maintenance of what remains a highly classified aircraft, despite its age, drawing on official technical documents, and narratives from experienced aircrew and maintainers. With the aid of detailed photographs and technical illustrations, many previously unpublished, the B-52's airframe, avionics, weapons systems and engines are covered in unparalleled detail.

Steve Davies is a freelance military and commercial aviation photojournalist and author. He has written more than a dozen critically acclaimed books, and has worked as an adviser for a range of military aviation TV documentaries in the UK and US. His photography has been used by the aviation press, and leading defence contractors and aviation corporations.

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